

ANALOG



SCIENCE FICTION AND FACT

JANUARY 2001

Relic of Chaos

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Nordley

Plus

Jack Williamson

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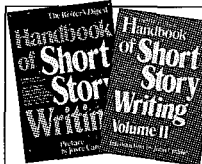
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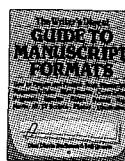


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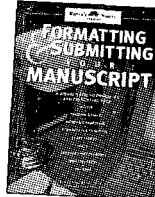
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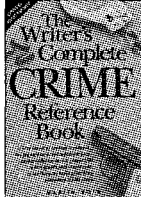
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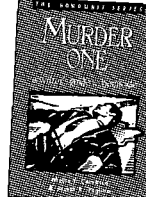
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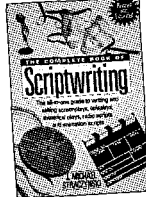
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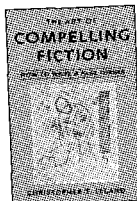
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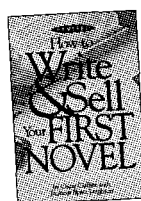
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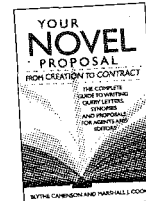
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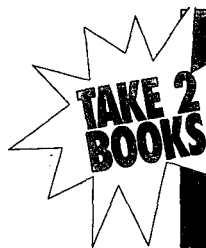
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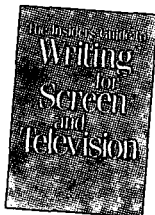


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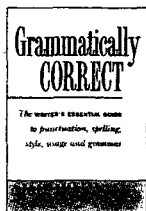
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the crew members have lost their captain
and their home...but the adventure continues....

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Political Entropy Revisited

Thirty-some years ago, John W. Campbell shocked many readers of this magazine (myself included) by announcing near the end of an editorial called "Political Entropy" that he was voting for George Wallace. Younger readers (or older ones with short memories) may not see why that was shocking, because they don't remember who George Wallace was.

For many years, during a period when the federal government was trying to eradicate policies of racial segregation, George Wallace, in a series of positions including governor of Alabama, was doing everything he could, including overt defiance of the federal government, to keep them intact. He later changed his stance quite a bit, but there was no sign of that in 1968. In 1968, announcing that you were voting for Wallace was a good way to sound like a rabid racist. Campbell had occasionally been accused of that anyway, but it had always seemed to me that the accusations stemmed from fuzzy misinterpretation of things that he actually said. The bald statement that he was voting for Wallace shook my faith in that.

That's the simple, first-order reason it was shocking.

The other reason was subtler, more complicated, and even more shocking: the statement came as the climax of a line of argument that seemed valid, important, and long overdue to be put into words. Campbell loved to do that: lead you down a logical path that seemed eminently reasonable to a conclusion

you just couldn't accept, thereby forcing you to recognize and try to resolve an inconsistency in your own thinking.

In this instance, Campbell claimed he was voting for Wallace not because of his ideas, which Campbell largely didn't agree with, but because Wallace was the only candidate who had any ideas that were significantly *different* from all the other candidates. Campbell drew an analogy between politics and thermodynamics. The amount of work you can get out of a system depends not so much on how much energy it contains, as on an uneven distribution of that energy. If all parts of a system are at the same high temperature, there's plenty of energy, but no way to get any work out of it. Doing work requires extracting energy from a high-temperature reservoir, using some of it to do work, and dumping the unused part in a low-temperature reservoir. Doing that, of course, lowers the temperature of the "hot" areas and raises that of the cold ones. Eventually everything winds up at the same lukewarm temperature, with no differences left to provide *usable* energy—a process usually described by scientists as increasing the entropy of the system.

Campbell suggested that for a society to do useful things, it needed analogs of hot and cold reservoirs, in the form of differing philosophies. In our country's youth, that condition was provided by two parties with different ideas about how to do things, the competition between those ideas being the driving

force that got things done. It further seemed to him that our country's "political entropy" had increased because the interaction between the major parties had drawn them philosophically closer together. Instead of offering radically different views of problems, they disagreed only on minor details, and that situation was unlikely to lead to any major breakthroughs in dealing with the big issues. His Wallace vote, he claimed, was not so much a vote *for* a defiant, racist politician as *against* a political system that had become too homogenized to do anything new or important.

Political entropy is not a perfect analog of real entropy, of course, but it is a neat way of visualizing a genuinely important concept. I'm still not convinced that voting for George Wallace was a good application of it (if enough people thought that way, he just might have won!), but there really is a danger in letting the country (or anything else) be run by people who all agree with each other. Even if the things they agree on are reasonably sound, they're not likely to generate any really new ideas because they're satisfied with what they already have. And if some of what they agree on is *not* sound, as is very likely the case, they'll just keep perpetuating old errors and drowning out any scattered attempts to correct them.

Some months ago I heard a new variation on the political entropy theme raised in a new context. The situation was a large-scale brainstorming session

involving several science-fiction writers and assorted working scientists, trying to imagine what problems our country and our world might face in the next few decades. I mentioned my concern about the danger of an ever more technological society being governed by scientifically and technologically ignorant people. In a world where questions of public policy increasingly deal with things like energy production and distribution, pollution control, global warming, genetic engineering, life extension, new diseases, and the industrialization of space, I find it scary that far-reaching decisions about these matters are often made by people who don't understand the first thing about them. And by that I mean both voters and their elected representatives.

But wait, suggested one of my fellow brainstormers. Maybe this is actually a good thing. If decisions about scientific and technological questions were made by people who do understand them—which largely means scientists and technologists—we might get a tyranny run by a power bloc of people who share one worldview and mindset. Large numbers of voters and officials who are not well-versed in science and technology can offset "the establishment," insuring that another perspective is brought to bear on each issue.

There's a certain amount of truth in this view, and it's refreshing to hear it from a scientist, but I can only accept it up to a point. Yes, fruitful discussions

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will not come from people who all agree, and to a certain extent the "scientific-industrial establishment" does (though not nearly as much as outsiders commonly suppose). Yes, almost any discussion will be enlivened by the injection of viewpoints widely divergent from the prevailing ones.

But not all viewpoints are equally valuable, especially when things reach the decision-making stage. Government by the scientific establishment may have its perils, but government by the scientifically ignorant can threaten an even worse tyranny of the majority.

Yes, we need to avoid indoctrinating everybody with the same biases. But let's not forget that there *are* such things as facts and evidence, even if nobody has a full and perfect understanding of them. There's a crucial difference between people who have examined the facts and see them differently, and those who simply know nothing but feel qualified to have opinions anyway.

The useful dialogues that can lead to wise government will not be between those who understand how things work and those who don't. They will come instead from those who have looked at the available information, made an honest effort to understand it to the best of

their ability, and view it from different perspectives that give them different ideas about what it means and what should be done about it.

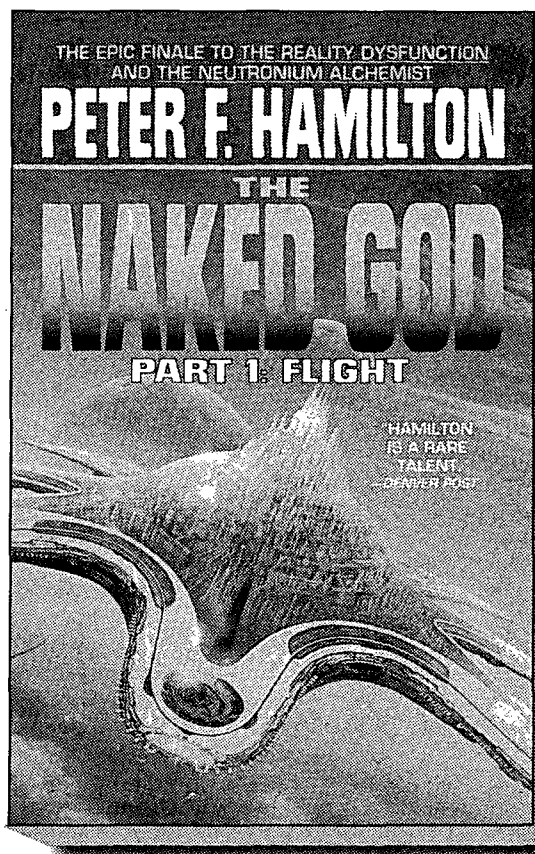
So: how can we have the strength of informed decision-making without the dangers of reinforcing each other's shared biases? As with so many real-world problems, there is probably no simple, optimal solution. But cheerfully encouraging the blissfully ignorant to remain so, while participating in decision-making on an equal basis with the well-informed and conscientious, is too simple and too far from optimal. We can and must do better.

The key, I suspect, lies in education, at a rather subtle level. We need to try to teach as many people as possible as much as we can of the facts as we understand them—not rote-memory facts like the boiling point of nitrogen, which can usually be looked up if and when we need them, but the *principles* that make the world work. But while attempting to do this, we must explicitly recognize—and transmit the recognition—that it's impossible to teach facts without also teaching hidden biases. We must try to *unhide* those biases, pointing out not only what we think we know, but why we think we know it,

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*Fraud and murder create hard enough mysteries
when the people and objects involved are unique.
When they aren't*



Relic of Chaos

G. David Nordley

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Consider the moons of Saturn. Waiting in the airlock, I could see their entire range; from the crescent of giant Titan, bigger than the planet Mercury, and iceballs half the size of Luna, on down to flecks of dust so small that electric fields could lift them above the ring plane to form spokes, clouds, and other transient ring phenomena. They are uncountable and nature adds more moons with every meteor impact or collision between ring particles. Humans didn't start adding to Saturn's brood until the dawn of the 21st century, but we've been making up for lost time

The biggest human satellite, of course, is Saturn High Station. It keeps time with the small moon, Mimas, circling Saturn some sixty degrees behind that battered icy ball in a few minutes less than a day. But its orbit lies in the plane of Saturn's orbit around the Sun, inclined to the ring plane by some twenty-seven degrees. So Saturn High Station bobs up and down relative to the ring plane, and gives folks a good view from above and below the rings, with a total solar eclipse every day thrown in for good measure.

The other human satellites around Saturn range from major scientific research stations down to derelict spacecraft, dropped tools, and golden crystals of discarded urine. Some of these satellites were fully planned, designed, coordinated, approved, linked and cataloged. Others are the result of accidents, or worse.

I deal with the "worse." I'm Hartigan O'Reilly, chief of security around Saturn. This satellite was a gray space suit with red detail; as our bright yellow and white striped motile handlers brought it closer I could see what type: a prospector version off a standard intersystem shuttle, with fuel cells, power assist joints, waste management system, and all the other amenities. You can live in it for a week with a full load of fuel, oxygen, and water.

Unfortunately for the sole occupant of

this satellite, its limpness told me it held no significant air pressure but there was frost on the faceplate; that takes about ninety minutes after heaters fail out here. I took a sniff of the freshly cleaned room-temperature air of my own suit, just to reassure myself. In another hour, the frost would sublime, so the time of death would have been about two hours ago, plus or minus thirty. Of course, I already knew that; just confirming theory with fact. Saturn, Chronos, Time, the grim reaper . . . But I'm getting ahead of myself.

It all started when a "Father Gannon" queried my autosecretary for an unusual in-person appointment for him and his staff. What was unusual was that he was at Saturn High Station, while my offices are on Hyperion, the small satellite with the random rotation just beyond Titan. I live there because my wife, Kate, works on patterns and chaos at the Hyperion institute. There's not a lot of crime around Saturn, and most of that we import with other curiosities from the inner solar system. With a few part-time deputies and AIs to help me, Hyperion is as good a place as any for my office.

But why in person? Gannon said he'd rather not deal with ten-light-second gaps in his conversation and there was much to discuss. He uploaded his brief to Watson, and after a glance at the lurid material, I agreed we had a problem. The case involved a murder on Earth, flight, and theft of a priceless relic that Rome now believed to be on Saturn High Station.

Further research revealed even more of interest. I returned his call and invited him up to Hyperion. We had something to talk about, indeed.

Three days later they were in my office reviewing the crime with me. Gannon, a tall, somber technical expert named Herman Edelson, and Oporto Dimundi, the Roman Catholic chaplain at Saturn High Station. Everything about

Gannon seemed soft; the rumpled black coverall, the loose flesh on his face, his easy gestures and his fuzzy voice with its light Irish tone. He'd made no effort at hair restoral, and so nature had given him a more or less monkish look. Dimundi was a small sharp man with a thin, almost beaklike nose and dark eyes which darted here and there, taking in everything. Edelson was tall and reserved, almost courtly in his manner, and seemed vaguely uninterested in what was going on.

They all sat in web chairs beneath an image of St. Peter's that I had Dr. Watson put on the wall screen behind them; my way of keeping their allegiance in focus. They sat uncomfortably, shifting and fidgeting. It might have been the low spin gravity, I thought, but, more likely, it was the subject matter. The morgue view of the various limbs, fingers, and other parts of José Zapata would unsettle anyone, me included. Even when I'd been working homicide back in the Cis-lunar Republic, I'd never seen anything that bad.

"I think we've seen enough, Dr. Watson," I said, and my cyberservant mercifully replaced the corpse with an exterior view of Saturn. "According to the report, the victim was still alive when that started, so the perp has motives beyond theft, it appears."

Gannon looked distressed, but merely said, "So it appears. This is a replica of what we're looking for." He held out a small, intricately carved wooden box.

I took it and turned it over and over in my hand. There were Hindu images carved all over it, including Shiva, the destroyer.

"Death, dismemberment, ransom, betrayal, and now anonymous threats. You spin quite a tale, Gannon." I handed the box back. "People think the original of this has magic powers?"

"The power of faith is not in the relic," the priest said in his soft high voice. If his English had any trace of an Irish accent, I couldn't hear it; he spoke

North American standard. "The power is Christ. The saintly relic is a . . . a focus or a conduit, if you like, for those who believe. When you pray . . ."

I held up a hand. "Despite my name, Gannon, there hasn't been a Catholic in my family in five generations, and I don't pray. I try to use my head. But what I believe or don't doesn't matter. What matters is what the thief might have believed. Did he take the relic for its magic? Or just to sell?"

The priest frowned momentarily, then resumed his friendly demeanor. "They want a ransom for it, now. But why they took it in the first place, I would not be so sure; there is always a kernel of belief in the soul that responds to the power of such an object."

Dimundi nodded. "I was born on Earth where tradition is strong and people often did things the old way to keep their culture alive. I fished on the sea in an open boat in the Sun with nets for years. Not to survive, but because my father did and his father before him and so on as far as we have records." He smiled. "We threw the wild fish back, except for what we ate ourselves. Sometimes you can lose track of *when* you are, and your heart believes things your head does not."

I sighed. "Sometimes people's hearts make them do things they know are wrong. Very well. Gannon, as you reconstruct things, Zapata stole the box from its display in the New Vatican Office Building and was later murdered for it by unknown persons."

He nodded. "María Sánchez found a copy of the relic in her bags after she and her husband arrived at Saturn High Station. Thinking it real, she put it on her altar and was a wee bit reticent about notifying us, though as you will note, she finally did. In the meantime, we received a ransom note from Saturn, with evidence . . ." he held up a hand and shook his head " . . . admittedly fable evidence, that the real relic is indeed out here."

Well, maybe, I thought. "So you suspect the real relic did come out with María and that the objects were switched before you tested it and that María Sánchez and her husband are either dupes or want you to think so. You're certain on the provenance of these objects?"

"There is a bloodstain on the real box which was of the blood of holy Saint Teresa of Calcutta. The box was a gift from one of the street people she cared for. The story is that she once cut her finger on a piece of paper and then touched the box, hence the stain in the upper left hand corner." Gannon nodded to his technical expert. "Mr. Edelson?"

Edelson ran a hand through his mop of sandy hair before he spoke. His hand appeared rough, and well used, but it's owner had a manner of classic Austrian refinement. He picked up the box and pointed to the bloodstain.

"The shape of the stain on *this* box does not exactly match the shape of the stain on the original, and the DNA of the blood does not match that of Saint Teresa of Calcutta. It does match the blood of Zapata. There can be no question about the results. I authenticated the original relic myself twenty years ago. This is a fake by someone with some knowledge, but not with high standards."

I looked Gannon in the eye.

He waved a hand. "Zapata worked for the curator. Father Dimundi would know it well enough, too. Hector Sánchez deals in such objects."

"And María with him," I added.

Gannon coughed. "No, María seems far too innocent to have had much of a role in this."

There is innocence and then there is innocence, I thought. "She kept the object at first. And according to the brief, she knew the original thief, Zapata."

"They were acquainted." Father Gannon fidgeted even more.

I almost didn't need his answers; I could just watch his body. "How well?"

"I am not really at liberty to say," Gannon's voice said, but his body told me "intimately."

I thought then might be the time to dole out a little of my research, just to inhibit further evasion concerning the things I needed to know to do my job. I spread my arms. "Zapata was also married to someone else, so I know that can be delicate. And you were María's confessor for a time, and I know that can be delicate. But Zapata is dead and cut to pieces; an object of great historical value, at least, is being held for ransom; and it's all on my desk now. So help me, Gannon."

He looked up for a moment, then back to me. "You will have to draw your own conclusions. Of course, you could ask her yourself."

His look told me that was all I was going to get from him on that. I thought furiously. If María had been Zapata's lover, then she was unlikely to be his killer, but her husband might be. Knowing the explicit details of the affair wouldn't change "might" into "definitely."

"There are at least two records of domestic violence because she was allegedly seeing other men."

The priest looked away again, then back. "They say one should be careful of what one asks for." He sighed. "I had to ask for a good detective." He paused and shut his eyes briefly. "Very well, I was sent because I am an experienced investigator but also because, while I cannot divulge all I know of María Sánchez, I can still act on it in a matter of such overriding importance to the church." He sighed. "But I have not been a very good detective in this place, as my last month out here shows." He paused to rub his nose. "It is a matter of public record that María's marriage has not been happy. She has sought occasional release with others and berates herself for it unmercifully. I give what comfort I can. None of her friends, to my knowledge, could be involved in cutting up

Zapata."

I'd need to check that more thoroughly later, but I sensed I was getting an honest assessment from Gannon. "We can leave it at that for now." I held up the box and turned to the expert. "Aside from the bloodstain, how good a copy is this?"

Edelsohn shrugged. "The wood is North American white pine of the right age. As with the original, the carving was done by machine in a factory in Korea, perhaps by the same tool. These boxes were stained to resemble a more expensive tropical hardwood, warehoused in Bangalore and sold to street vendors at a 300% mark-up. The vendors then squeezed maybe another ten percent out of it. There were literally millions of them made in the twentieth century; the only clearly unique things on the relic are the pattern of the grain, its wear, and the bloodstain. But those would be impossible to match exactly."

"Some would include as unique," Gannon added, "the spiritual essence of the relic, which is subject to higher powers of identification."

"On demand?" I asked and immediately regretted the sarcasm.

Gannon frowned deeply, tightened his lips and said nothing.

Careful, I told myself; If I was to get anywhere on this case, I'd need Gannon's willing cooperation.

Edelsohn touched the priest on the arm, which seemed to calm him. "The data—the quantifiable data—on the relic has been uploaded to the Saturn High Station system—a highly protected file, to be sure, but available without a three-hour lightspeed delay. You have access to it."

I nodded briskly. The tall Austrian seemed quick on the uptake—a likely useful ally in this.

"What do they want for the real relic?" I asked.

Gannon looked very uncomfortable now. "I've gotten a demand every day since I've arrived—I'll be looking at a

vista, or just completing a call and suddenly there it is, on screen, making its demands."

"What?"

Gannon smiled weakly. "Now before you start thinking I've lost my sanity, I'll assure you that I know it's just a construct, a hologram, but what shows up is a devil's head. And it speaks. It tells me they want unfettered access to all the Vatican archives."

It figured. In past ages, money would have been demanded; but nowadays that could be traced too easily. "I suppose there's information in there that could be used for blackmail."

"And worse," Gannon added. "It is a very delicate time to be talking about such access. Pope Julius IV has just celebrated his 115th birthday."

"Yes," I said, unsure of what he meant. "It was on the news. He waved from a window."

"Some thought they saw him raise his arm in blessing when the nurses wheeled him in his bed to the window, and, yes, that made news throughout the solar system. But people have been talking about candidates since the holy father took to his bed. The curia is near evenly divided over ordination of women, names on both sides have been floated, and the whispers have risen to a babble. I am ashamed for the church."

"To some, great spiritual necessity can justify acts otherwise unthinkable," Dimundi said.

"People who could sacrifice themselves might also sacrifice others," Edelsohn added.

"I've got the picture. Reports of a girlfriend from fifty years ago or some such nonsense could probably undo a candidate."

Gannon winced, but didn't dispute it.

I smiled. "What else would the access be good for?"

"Investment information; real estate on Earth is one of the few things that robots cannot make more of for nothing; the Church has a great deal and gets

more through inheritance. We sell less than we get, but even that has created a liquid endowment, the motions of which affect markets worldwide. Locations, descriptions, and security precautions of authentic church artifacts and treasure would be highly desirable to thieves, of the sort, perhaps, that stole this one. There are detailed plans of numerous buildings of interest to saboteurs, assassins, and potential purchasers. One might find embarrassing admissions for theological enemies." Gannon spread his hands. "It would be what any invasion of organizational privacy would be, except on a grand scale."

"To use that access without being detected," I said, "they'd have to know what they were doing."

Gannon looked me in the eye and nodded. "We visited Gwen Chryse on the way here."

I pursed my lips . . . so Gwen was already involved. The reigning queen of the Hyperion institute was also the focus of a formally nameless philosophy of loving intentionality with which she hoped to tame what she saw as a mindless and chaotic Universe. She had somehow managed to fuse reason and feeling in a way that wasn't, that couldn't be at odds with external reality; it was revelation-proof and attracted more adherents every day. Even on Hyperion, popularity had caught up with Gwen, and she had reluctantly turned to filtering her visitors.

"That's a difficult appointment to get. My wife, Kate, is a top-rate cyberneticist and I usually ask her such questions first. It might have been better to go through my office."

Gannon shrugged his shoulders and smiled. "But surely you would not want me to come here without my homework done? Oh, I'll admit that my philosophical curiosity played a part as well, and it seemed an opportunity. Be that as it may, our opponents can do the devil's head so we think they would probably

have a person or people in the Saturn system who, perhaps, have been here for some time. You have, of course, lists of all the arrivals over the past two years? And can check for anti-Catholic communications? Ms. Chryse would rather have your approval before doing that."

I smiled. That was Gwen's affection and self-restraint in action. Lack of official approval alone would never stop Gwen from getting any data she wanted. "Published communications, yes. We can't record private com." Could Gannon? Back in the Vatican? I wondered. "Of course, the perps know our network already." I exhaled. Time to take a break, think, and get some help. "A tiger by the tail. Enough for today?"

Gannon looked around at his people, who remained silent. Then he smiled and nodded. We made our goodbyes and they left.

I sat and stewed.

Kate might be able to check out the various cybernetic systems. Under her ministrations, my cybernetic assistant, Dr. Watson, had begun to pass all but the most subtle Turing tests. Kate was a functionalist; she made no effort to mimic the physical structure of the human brain, but thought it simpler to emulate the functional logic of the various pieces of our minds with her "mobjects," modules of code that were to software objects what those were to subroutines, an analogy that did me little good other than to convince me that if anyone could find out who was literally bedeviling our communications system, she could do it.

And if she couldn't, Gwen Chryse could.

Gwen's quarters now occupied a twenty-meter-long wedge on the outer section of Hyperion Dome's spinning bowl. Kate and I passed the filter; we'd been with her back when she had been paralyzed by a bullet in the case that first brought me to Hyperion. Kate was my

soul mate; a fellow refugee from the pain and misery of the frenetic pace of the inner solar system, and she'd come with a mission, seeking freedom of thought and time to work on her dream of freeing the human mind from what she called its limited and unreliable organic prison. Gwen had brought us together.

We hung our clothes in Gwen's anteroom and entered a room large enough for all fifty-eight of the programmers at the institute to meet in—but it remained as stark, bare and minimalist as Gwen herself. The end of the room was the inside of a large hollow quarter-sphere, like a band shell, with Gwen at its center—a full, high-definition holographic interface node.

Her hair, lightly frosted by her temples with honest age, trailed down her back to the floor, and as she turned, her face showed some character lines as it crinkled into a grin. She still used an old-fashioned interface coronet—a simple gray band that circled her head above her ears and read her brain waves. No foreign objects in Gwen Chryse's body, thank you. With angular features, a hook nose, and eyes that were too far apart, she had never been beautiful, but age had filled out her former wraithlike skinniness to something resembling a normal figure and her smile was pure delight.

The Universe felt different in her presence; it was as if by sheer force of her will, she had banished all embarrassment, jealousy, hurry and pretension and established a sphere of good will some ten meters around her. She flowed out of a lotus position to her feet and embraced us.

"Almost a month," she said. "Is crime getting that common out here?"

I shrugged. It *had* been too long. "Life gets full."

Gwen nodded. "Ah . . . so full it becomes empty. Well, Hart, if your relic is in the possession of its thief, it should still be on Saturn High Station—we've

analyzed the communications delays and their syntax, and while there's been an effort to disguise both with spurious data, the likelihood is in the high eighties that they are coming from an individual on the Station. By the way, did you know that Hector Sánchez knows about Father Gannon?"

That was prototypical Gwen, jumping from subject to subject as if the connections were obvious to us mere mortals. "His wife's confessor?" I asked after I caught up. "I imagine he would know the name."

Gwen gave us a cat-who-ate-the-canary smile. "Conversations with one's priest are entirely confidential and unrecorded, but the public areas must be under constant surveillance, and the records of who comes and goes are available. Now, based on the time they've spent alone together, and external physiological clues visible after those sessions, it seems very probable that Father Gannon has been one of her lovers." Gwen sighed. "Context creates crime. The most gentle and natural can be ugly and dark in the wrong context. Hector filed a complaint."

"With whom?" Kate asked with a knowing smile. Kate had known Gwen much longer than I; she knew what Gwen was thinking almost as fast as Gwen did.

Gwen smiled. "His superiors. It turns out that Father Gannon is way up in the Oculus Curatoris."

At a blink of her eye, an organizational chart of the Roman Catholic Church, Anno Domini 2118, filled the display in front of them, complete with holograms of all the officials from Pope Julius IV on down to the Catholic chaplain of Saturn High Station. There were only three people between Father Gannon and the Pope.

Another thought struck me. "This Oculus Curatoris—is that the successor organization to . . ."

Gwen nodded. "The Inquisition. They changed the name in the twentieth cen-

tury, and then again in the twenty-first. Oculus Curatoris is literally the eye of the overseer—the office was created in 2074 to consolidate Vatican intelligence activities; they handle espionage, financial problems and ethical lapses as well as doctrinal excursions. They listened politely to Hector.”

The Roman Church was hardly the world power it had been a thousand years earlier, and Father Gannon didn’t seem the type to be ordering thumb-screws turned and racks tightened; still the power of that history ran a slight chill up my spine. A real-life inquisitor.

“Then Gannon must be too good to fire.”

Gwen nodded

“And,” I added, “he would have known about you when he came to me.” While Gwen’s philosophical movement shared many general principles, such as the golden rule, with Christianity, their ‘thou shalt nots’ were sometimes her ‘thou shalt’ and vice versa. “Working with us must be a stretch for him.”

Gwen shrugged. “They’ve talked with me. Your Father Gannon is a very complex man. And he has a suspect.”

I nodded. “Hector Sánchez, of course. He beats his wife. Three arrests.”

“And she stays with him?” Kate asked.

Gwen sighed. “He saved her life, once. Also, they lived in one of the few places where marriages still last beyond love. I think that Father Gannon did what I or any of us would do for María, except that he berates himself for it.”

Not as much as Hector Sánchez berated him for it, I suspected. And not enough to recuse himself from the case. “It seems that men are willing to do any number of things for María Sánchez.”

“Well,” Kate said, with a twinkle in her eye, “you’ll just have to check that out, won’t you?”

I grinned back at her; our mutual disdain for sexual jealousy was, paradoxically, one of our strongest bonds. Hers was philosophical, mine came from hav-

ing to deal with the corpses of people slain by jealous lovers. “Not,” I answered, “if I can solve the problem here. They’ve been getting ransom messages throughout this system.”

Gwen raised an eyebrow. “I know. They visited me, too.” Then she frowned. Something in the display was clearly bothering her. She concentrated on it, a vast three dimensional array of nodes, symbols and connections. At length she said. “Kate, don’t feel bad about not finding it. There’s nothing I can find either that could be our devil-maker.”

“Lying low?” I hazarded.

“Possibly. There’s no record of any suspect messages coming to Father Gannon—some secure stuff, but that’s all from Rome. No code to route the ransom messages outside our communications net either. No gaps in the record. Null can’t find anything, either, and she lives there.”

I smiled. My loving wife has undertaken a project to make Gwen immortal, as a cybernetic being with thoughts and memories indistinguishable from those of the original. It was the sort of controversial cutting-edge research that was nearly impossible to do in the inner solar system these days, but that the isolated Hyperion Institute could risk. With her usual good humor, Gwen had embraced the project with one condition; until such time as her body dies, the double will be known as “Null Gwen.” But already, Null handled much routine correspondence for Gwen, uploading her doings to Gwen in her sleep. If Gwen has ever disagreed with Null, she has kept that to herself.

Gwen froze and pointed to a window that had appeared on her display.

My smile vanished. A red, horned disembodied head, half human and half goat, formed in front of her screen. “Don’t go there,” it said, “just let me have the data and no one gets hurt.” It vanished in a puff of virtual smoke.

Gwen was silent a while. “Null?”

"What is it, Gwen?" Null answered.

"You didn't see that?"

"What?"

Chaos, I thought. Who would be good enough to use the system to do that so smoothly that an AI that lived in the system would be unable to detect it? Someone had to state the obvious, so I did. "It's in there and he's heard and seen everything we've said and copied everything we've done to date."

Gwen nodded. Then she got up, removed her interface coronet from under her hair, glided over to a panel in the wall, opened it and methodically disconnected three wires. The holographic display vanished, leaving us in a bare room that seemed somehow colder. Gwen stayed at the panel as if frozen, the last wires still in her hand.

She was so used to the interface, the connectivity, and using the system as an extension to her mind, I thought, that it must have felt like a self-lobotomy. I went to her, gently pried the connections from her hands and took her into my arms. There were tears in her eyes. Kate came to embrace both of us.

Finally, Gwen took a deep breath and said, "I think I should come to Saturn High Station with you."

"Huh?" I looked at her. Since when the hell was I going?

"There's a ten-second round-trip light-speed delay between Mimas orbit and Hyperion. We'll need to be much faster than that to catch this devil, or . . ."

I laughed and tried to lighten her mood. "Gwen, you don't believe in devils."

But Gwen looked very pensive. "Whatever direction you choose in life defines an opposite direction; your devil lives that way. Yes, that was an image. But a devil, of sorts, lies behind it."

I nodded. There was one thing I'd recognized on that organization chart before it disappeared—the name of the Catholic chaplain at Saturn High Station; Oporto Dimundi. With the system down, I couldn't check, but I thought

he was a cyberneticist.

A day later, Gwen, Gannon, Kate and I met at a rooftop park on the bowl rim. The bowl spins to keep buildings and people pressed to its side in the astronaut's time-honored substitute for gravity. So our "ground" was nearly vertical to Hyperion's own minuscule gravity; to one side of us was the microgravity forest that filled that bowl and on the other side, infinity. Hyperion's chaotically appearing night had happened to coincide with the more regular local night that people and plants need, and the stars spread out so numerous and bright in our night-adapted vision as to hide the constellations we use to locate them. They wheeled up and down with the relative motion of the bowl like a time-lapse video taken from any point on Earth's equator.

Gannon sighed. "You've found nothing, Ms. Chryse?"

She shook her head. "Whatever does this appears, does its thing, and vanishes without a trace. Null found nothing, and shut herself down in case she herself might have been contaminated. I've had to stay out of the system lest my inquiries themselves reveal our efforts. I've been taught a lesson in hubris, it seems."

She seemed recovered now, but Gwen's loss of her link and the loss of her cybernetic sister had moved her to tears. It was, to put it mildly, unnerving for Kate and me to console the person from whom we had most often sought guidance and consolation ourselves.

That called for drastic measures, I thought. "Time to bound the problem, I think."

"How?" Gannon asked.

"He's running our system? We shut the system down. Level the playing field."

Gwen's eyes went wide, then she smiled. "With the system down, he'll be as deaf and blind about what we're doing as we are about him!"

Gannon looked horrified. "But don't you depend on your computers to maintain this . . ." He spread his arms. ". . . artificial environment?"

I smiled. Part of my security job was to know this stuff in case of emergencies, and this looked like one. "Over the long term, yes. But it's big—lots of momentum. And the Sun's up in a few hours. We'll have light. The spin of Hyperion dome's bowl will gradually decay, but inertia will keep centrifugal gravity near lunar levels for days. With the Sun up, contingency plans should give us a week plus before there's any significant degradation."

Kate touched my arm. "I think I know what to do. I'll tell you after the shut down."

The three of us were grinning like Cheshire cats. We had a plan.

Gannon shrugged. "I have a meeting with Dimundi later—he's here on church business and we were going to return to Saturn High Station together. Might I be permitted a call?"

I looked at him sharply, but he seemed totally innocent. I shrugged and nodded. Gannon said his farewells and pulled out his com card as he walked away.

We asked for and got a precipitous four-day shutdown of the Hyperion institute; all power, all computers, everything. Word of what had happened and why was circulated by word of mouth. There was presumably some inconvenience and irritation, but with everything down, the irritated had to go to us physically to vent, and almost nobody did. Maybe the exercise cooled them off, and they went back.

Presuming that we'd blinded our enemy, with our own hands and rolls of foil, we turned one of Gwen's inner apartments into a Faraday cage, completely shielded and isolated from the outside. Outside the foil we placed numerous microtransmitters that could provide a chameleonlike simulation of normal activity.

Inside that shelter, we produced a portable, uncontaminated high-end system that we could carry with us. We used the brains from a scrapped ion-drive freighter, scrounged a dozen Opticor 72069E cpu's to augment it, and uploaded a five-year-old backup of Dr. Watson to run it and renamed him Danno. Gwen made software updates from memory, with Danno's help.

We briefed him orally on the situation. He got no unmonitored software or firmware newer than three years before theft of the relic. Danno could create agents which we could outload on data wands, but he was otherwise physically isolated from anything our adversary could do. And we made two of him.

That done, Kate suggested we make a trap. "We have a licensed replicator at Hyperion, which can be entirely isolated from the main system. Danno can provide the higher order functions. We have a nearly down-to-the-molecule description of the relic. If we can get the Vatican's permission . . ."

I smiled. ". . . we can make the perp think that we had found the relic. He or she would be put off balance and maybe even rush to check the hiding place."

"It will take a day or so, but it's not particularly hard to do," Kate said, "which makes me wonder why whoever did the forgery did not take the trouble."

I looked at her, eyes wide. "Both the simplicity and the blood point to a Sánchez."

"Exactly," Gwen said, "but are we supposed to think *that* or are we supposed to think *that* is too obvious? Or might there even be three layers to this subtlety?"

I nodded. "I doubt either Hector or Maria is responsible for the devils, but one or both might well be working with whoever is."

I said goodbye to Kate the next morning with the sort of nothing-left-unsaid tenderness we give each other when I

head out into risky situations. We didn't kid ourselves; we were up against a murderer who treated the computers of the Saturn system like his own personal agents, and something could happen to me at any time. She was at peace with this; our love would go on, my memory would be honored. I couldn't ask for more than this of a cop's wife.

Gwen, Danno, and I took an over night shuttle to Saturn High Station to join Gannon; we would try to recover the artifact and identify the murderer. Kate and Danno-2 would stay and try again and again to trace the perpetrator through the devilish calling card he'd left there.

We woke to one of the more impressive pieces of architecture in the solar system. Locals call Saturn High Station "the Silver Rose," and it looks a bit like that from the outside, with its stem pointed toward Saturn. The flower petals are the giant thin-film mirrors that concentrate sunlight a hundred times for the agricultural wheel, a donut of glints and greens rotating in the base of the flower. As our shuttle slipped behind the "petals," the "rose hip" emerged, a near spherical radiation shield made of Mimas regolith, half-lit by Saturn. The upper part of the stem drew closer and we saw, far down-stem where the centrifugal force of revolution and Saturn's gravity balance, the vaguely leaf-like structures where spacecraft dock. To stretch the simile, from our viewpoint the various shuttles and liners cluttered the leaves like a bunch of aphids.

As we approached the dock, the habitat wheel came into view through the open end of the rose hip. The habitat rotates in the opposite direction from the ag module, so that the two cancel each other's gyroscopic effects and leave Saturn's gravity free to hold the long stem of the Silver Rose pointed at Saturn. At the end of the stem is a ten-kilometer ice and dust moonlet that provides most of the station's natural resources. Transparent elevator cars run

from the docks to the hub of the habitat wheel; we didn't get much work done as we alternately gawked at the station and Saturn itself.

The Saturn-facing side of the inner wheel provides a magnificent view to homes, offices, and parks. These were terraced like a Greek mountainside village, a cascade of textured white walls and blue trim that reached from the inner wall down to the narrow artificial sea that runs the circumference of the wheel. Through it, you can see the stem run toward Saturn like a railroad track to an infinite horizon, making the planet look all the more huge. So huge that though we were half as far from Saturn as Luna is from Earth, one had the illusion of flying over it. Backwards, though; the planet spun at about twice the station's angular rate, rotating completely beneath us every day.

We arrived about local noon, and the station gave us open quarters on the thirty-second terrace up; the beach front property goes to permanent residents. With a murderer on the loose, we went right to work. The Sánchezes would be our first interview, that afternoon, if possible. The Sánchez quarters and gallery were about a quarter turn spinward on the eighth terrace up from the "seashore."

We came into the gallery and looked around while Hector Sánchez finished with a customer. The high white walls were covered with an eclectic assortment of paintings. Something in the style of Gauguin hung next to an impressionistic "self-portrait" of a bare-backed young woman at an easel watching Saturn smeared into a series of concentric circles by the station's rotation as if in a time exposure, though still and recognizable on the canvas within a canvas in front of her.

We broke the ice with some small talk. It turned out the Sánchezes were brokers more than retailers; for a fee, they will find a home on Earth for your original painting of Saturn in the sky, or

arrange for the shipment of a certified, unreplicated terrestrial original to Saturn—a typical investment for many colonials. The studio sales were a small part of a business Hector seemed to know well.

Gwen asked Sánchez about his problems with María.

He shrugged. “Sí, sometimes when María gets a little too crazy, I do what a man has to do. I let her know I will not stand for it, and then we can get back to the art. People should not meddle in our affairs. If it gets to the point where I cannot take it, I will divorce her, church or no, but it has not gotten to that point yet.”

He gave Gwen an appreciative eye; her concession to the station custom against nudity away from the beach was a simple loose white cotton shift, generously scooped in front and belted by her belly bag. It highlighted her curves and did a fair job of hiding all the middle-aged sags and so, I thought, made her look even more sensual than she did naked. It certainly seemed to loosen Hector’s tongue.

“But until then, it is my business. Such nonsense she learns from that corrupt priest! It is not seemly for an adult woman to be babbling such nonsense about ghosts and demons.”

Gwen shot a look at me. I shook my head; I instantly thought of the carefully contrived apparition we had seen. María Sánchez could describe her own demons later.

“Me,” Hector continued, “I think I prefer what Gwen has to offer.” His grin was close to a leer.

“You were the one who found the relic,” I stated and waited for elaboration.

“Sí, except it did not fool me, no.” He snorted and waved his hands. “Hector Sánchez deals in art and knows it to be a fake. Saint Teresa of Calcutta died over a century ago. This was too new, too fresh. I could feel it, I could smell the wood.”

Utter nonsense, I thought. The fake box was as old as the real one! But I kept my mouth shut.

“Did you know the stain was Zapata’s blood?”

“Not until that expert brought by that hypocritical priest took a sample and compared it. Loco!”

“What is crazy?” Gwen asked.

“How could she fool herself into thinking it was real?”

“When you need something very badly to get through the next day,” Gwen said, “if you tell yourself you have it, you may at least get the sleep you need. If that is craziness, Hector, at least it is craziness with a decent purpose.”

He sighed. “Sí. But if only . . . I have Dimundi over here to talk to her every week. And talk shop, too. He makes these smart mobiles, he is good at that but I think he is as bad a priest as the other. Bah!”

He appeared to run out of words so I asked, “You made no mention to the authorities?”

Sánchez snorted dismissively. “Why should I? I knew it was fake! I told María so, but she finally believed so much that she called her priest and then by the most incredible bad luck we find out the real one is missing.”

I nodded to Gwen, who produced our artifact from her bag and handed it to Hector.

“Sí,” he said. “That is the . . .” His face got troubled for a moment, then he laughed and grinned. “See, you think you must test Hector Sánchez to see if he knows his stuff! This too is a fake, but it is not the same fake!”

“How do you know?” I asked.

“María, the superstitious, self-centered *puta* she is, when she gave up the first fake relic would not give all of it up. Oh, no. She plays her fantasy to the limit, she does. She shaves a small sliver off right here.” Sánchez pointed to an inconspicuous edge of the bottom of the box. This has no sliver missing.”

We asked a few more questions, of no

consequence, and left.

On the way back we reviewed where we were.

"If Sánchez is our culprit," I said, "he's a very good actor. But I don't believe he is guilty of anything more than an over-inflated ego. That leaves María, Father Gannon, or someone out of left field, which doesn't make sense, either. So, what about an intelligent virus—an agent for someone or a thing of its own, living in the system?" I thought of that devil's head. "It could use maintenance robots to do anything physical it needed."

Gwen shuddered. "There are so many safeguards . . . It's so hard to do; I don't think I could do it. But, well, I'm getting old."

I gave her a quick hug. This was not easy on her at all.

I went to see Father Gannon the next day, while Gwen hung out in our suite in case Hector Sánchez wanted to see her, and to try to help Kate trace the suspected intelligent virus.

I decided not to tell Gannon about the sliver María Sánchez saved, either. I didn't trust him fully, either in the sense of being a possible suspect or as the possible lover of a suspect who might blurt it out. Also, María's defacing such a relic when she thought it was real might be a serious issue between them—and I didn't want a tiff to interfere with the investigation.

The vivid blue door of the suite had a standard smart window; it could be transparent, opaque, or a holo tank as the local system saw fit. Gannon was apparently in a humorous mood today; the window was in holo tank mode and I could see a forest of red flames in the suite as I approached.

"Gannon," I announced. "Good morning. It's O'Reilly."

Then I lurched back from the door in momentary terror. The same devil's head I'd seen in Gwen's room at Hyperion thrust out at me. But this time it had

a body, back in its virtual room.

"I told you not to go there. Now look what you've done, oh now look what you've done!"

It gestured back to the flames. There was Hector Sánchez, gripping his throat as the flames jumped up around him.

The door opened.

"O'Reilly?" Gannon's soft voice asked.

I couldn't speak—I glanced at him and pointed toward the apparition.

But it was gone.

"O'Reilly? You look troubled."

I took a breath. "Our demon. It's in the system here on the Silver Rose and it just paid me a visit. Got caught off guard a bit." I held up my wrist com. "Danno, did you record?"

"Poor angle, but I got some of it. The data are off to Gwen and Kate. Might I be so bold as to suggest a medicinal scotch to settle your nerves?"

Danno had full access to my pulse, of course.

Gannon smiled. "Scotch is a little scarce around here, but would a shot of Bushmill's do ye?"

I began to feel a little better about Gannon.

"We don't stop being human beings when we put this collar on," Gannon said as he poured. "I've prayed over giving María Sánchez what she wanted and needed from me, and my prayers were answered in the contentment and relief I see in her eyes. Frankly, she is not so beautiful or personable as to tempt me from my vows, but her need is such that I am made to feel, as by some outward power, that I have given to her. 'In as much as ye do it to the least of them, ye shall have done it onto me,' our Lord said. Now there is sin and then there is sin, and I feel I would have sinned more to turn her aside. That is what I told my own confessor, and that is what I tell you."

"Gannon, help me understand; how does this square with your vow of celibacy?"

He gave me the biggest Irish grin I'd

ever seen. "But that is no problem at all, son. I have no intention of marrying her or fathering children by her."

I looked confused.

He nodded. "Ah, my problem is not celibacy, but that little venial thing about chastity, which, however, is no one else's concern. As I told you, I have prayed on it and I believe I have been answered. The Lord who makes the rules can ease them here and there when a greater good is served. I am at peace with our relationship."

His relationship with God or with María Sánchez, I wondered. "She isn't yours alone," I said.

"But of course she is not; she is still married to Hector, and you know there was poor Zapata."

I put my Bushmill down for a moment, trying to make sense of his candor.

"You look puzzled. I have spoken with María and Dimundi and she will bare her soul to you as needed. There is no point now in holding anything back, for you will find it all out anyway—give me enough credit as a fellow intelligence professional to know that much—and Hector could not beat her any more even if he should know all that he suspects. What we need now is to recover the relic and bring Zapata's killer to justice. The Lord will help us with our personal lives afterward."

As you want it, I thought. "OK, let's go back over the theft."

Gannon nodded. "The surveillance system was down entirely; indeed all the power in the building was down. However, the display case holding the relic has its own power supply and fingerprint access system with a voice recognition backup. Zapata's thumbprint and voice were the last to open it before the fake was discovered in its place. Unfortunately, the switch was not detected until María's conscience got the better of her and we tested what was in the display. But her relic turns out to be a fake as well." The priest looked upward

and shook his head.

"Anyway, the theft took place on a Saturday night and Zapata failed to attend his work the next Monday, and María and Hector departed Earth for Saturn that Wednesday night with the authorities suspecting nothing of their involvement. I was given the responsibility of investigation at that point. Our search of Zapata's apartment Thursday produced his remains—we had a hound, you see, and it kept barking at his refrigerator. We found the poor man in its cryo zone, his pieces wrapped as if they were nothing but so many kilos of synthefish. Now I tell you *that* was a sorry sight!

"So, I hope you'll be appreciating my dilemma. I knew of a link between Zapata and María which was hidden to everyone else, but I could say nothing of it myself. Then María announces all the way from Saturn that she has the missing relic—which only a very few knew was missing at all—and it had turned up in her baggage where someone had hidden it. I'm sure she would have made no such admission if she knew that someone had been killed for it!"

"Was he?" I asked. "Zapata's death could have been a coincidence. Let's say that Hector decided to settle his score with Zapata just before their liner left for Saturn. It was the only liner that month, so a Saturn-bound thief would have grabbed it, too."

"Ah, but then why would he have chosen María's luggage? That would be one coincidence too many now, would it not?"

I had to admit that. Common sense screamed that there was a connection. The trouble was that one of the most obvious connections was sitting right in front of me. Well, nothing to do but press on.

"Gannon, have you ever investigated a killing before?"

He looked up at me with the face of someone who'd been there. "There was an apparent suicide of a young boy

who'd had no reason to kill himself. I'd have given anything not to have found the cause of that and I'll trouble you not to make me relive it now. It'll be in the files.

"Now, I'm surprised you haven't spied that one out, son. I shall make no apologies for the fact that I know all about you from your comet lady to that mathematical impostor and I shall make no objections that you learn everything you need to know about me." He smiled. "It is what a professional would do, is it not?"

I smiled in spite of myself. "Your files are well guarded, Gannon. That's the whole point of this, isn't it?"

"Aye, I suppose it is. No one is going to hack into those files, so if one has to have them, I suppose the ransom is understandable. But now crime is your profession more than it is mine, so what do we do when we can't find anything that makes sense?"

"Look at the data again and see if it generates any more questions."

It was near local midnight and we'd put off the ugliest part of the review until last. But finally, there was no putting it off, and we went over the sadist's handiwork again. The fiend had been thorough, even to the point of hacking the jaw from the skull.

"Done with a serrated knife, they say," I mumbled.

"So it was. Since you don't pray, I don't suppose you believe in demons either."

I opened my mouth to make some noncommittal response but he saved me the trouble.

"I'm not claiming any personal experience, mind you, unless this might be the first, but I know no one in this case with so much hatred in his own heart. This is unnatural, with not even a hater's logic to it. Every little bit . . ." He stopped short.

"What is it?" I asked.

"I've seen this a hundred times and

only now do I see what's there. Do you see how the investigators laid him out in rough order, as if he were a vehicle and they were trying to reconstruct the reason for his crash?"

It seemed obvious, but I've been doing this long enough not to question the obvious. "Yes?"

"Well, now, I'd say something's missing. Look at the left hand."

I saw an ugly piece of bruised meat with four disarticulated fingers . . . and I felt like an idiot. "The left thumb is missing."

"Aye, and a toe, an elbow, an ear, a ring finger on the other hand, and, of course the genitals . . . but I have a wee suspicion that was all just to confuse us. The left thumb was what opened the display case. Now, it may be coincidental, but . . ."

I held up a hand. "For the last fifty years, Gannon, those locks have required a warm, living thumb with a pulse."

"So they have. I wonder if it might be fooled some way."

"They're generally zero access—no links to anything else—for just that reason."

"So what it saw had all the characteristics of a live, throbbing thumb with Zapata's print. But now let us suppose it was Zapata's thumb. Could it be put on another hand?"

I began to understand why Gannon was so high up in the Inquisition, excuse me, the "Oculus" whatever. He was good, and worse for another he was after, he was deceptively good.

"Someone," I answered, knowing full well that Gannon was just trying to throw me a scrap of the game, "would have to cut off his own thumb and have Zapata's transplanted on the stump."

Gannon nodded. "A certain amount of motivation required, no doubt. And would that not then leave a person with the wrong fingerprints?"

I thought shook my head. "When he was done with it, maybe he'd cut off Za-

pata's thumb and reattach his own." I shuddered.

"A gruesome thing that is, but I fear this is a routine surgery nowadays on Earth, however macabre it sounds. These bodies God has given us are but another machine to tinker with."

I stared deep into Gannon's quiet eyes, a million thoughts in my head. We were a far frontier society, and while technology reached us at the speed of light, those changes in fashion and mores that we did not generate ourselves trickled in at the end of months-long voyages as hitchhikers in the minds of people who were often deliberately fleeing such changes. On balance, we had become conservatives out here in spite of ourselves.

Gannon lived in the heart of it and, as both a priest and a cop of sorts, knew the worst of it well. If he chose to believe in devils, so be it. He undoubtedly had his reasons.

Scars. I had seen a scarred pair of hands, not all that long ago. But whose? I could not remember. Be that as it may, it wouldn't have happened instantly. "I'll have them look for incongruous prints."

"María tomorrow?" I asked. "I agree she can't be that cold butcher, but there's a connection, somewhere."

Gannon closed his eyes briefly and nodded. It would not be easy for him.

María Sánchez was dark-haired, twenty-seven, full-figured, and scared out of her mind to see Gannon. She trembled as she showed us into the shop. It was like stepping into a museum, with walls crowded with paintings and shelves cluttered with artifacts. I spotted what looked like a Sumerian signet stamp next to some miniature padded exercise weights of the sort lunar infants used to use. They had one of the first comm pads—wider and thicker than a big man's hand, a dial telephone, nineteenth and twentieth-century office gadgets, a 2025 Boeing personal emergency reaction engine . . . I had to tear myself

away.

"We are all dead," she said.

"How so?" Gannon asked.

"El Diablo, the image that comes unbidden from the wall screens, says that anyone who cooperates with him . . . " she pointed at me, " . . . will die."

"Now," Gannon said with a gentle smile, "we might have a little to say about that."

"He . . . " she pointed at me again " . . . thinks this is just some clever trick by some bandito. Someone should tell him the devil can use electronics, too. All the electronics do is make it easier for him."

"María," Gannon said, "besides me, who knew that you and Hector were going to Saturn?"

She stared.

"Your family?" I asked.

Gannon held up a hand and shook his head. "Her family were the street pimps of old Mexico City. Hector bought her there."

"Bought her?" Mexico City in the twenty-second century was a typical world-culture town; a quaint historic park studded with gleaming white kilometer-high arcologies that housed upwards of fifty millions, last time I'd noticed.

"Some commodities," Gannon said, "will always be scarce enough to attract suppliers. Surplus girl babies, often the product of unfortunate pregnancies among faithful, but passionate, people, are sold and raised in orphanages with ties to the suppliers. Regulators look the other way, and the girls are on the streets at fourteen. María has no documented family."

"Sí. Hector was looking for Aztec artifacts and he found me. I was good. So he bartered something he found and gets to keep me. Later, we go to Rome to sell artifacts and meet Hermann and Father Gannon and he marries us. But that is, what you say, formality; Hector does not love me, he owns me. This is OK because he saves my life. Love I can find elsewhere."

"María," Gannon said, "you don't have to . . ."

"Mr. O'Reilly . . ." She turned to me and stabbed me with the most smolderingly intense stare I've ever gotten from any woman. "If you could keep this devil away, I would reward you, and it would be worth it." She laughed, a clear high peal of bells that clashed crazily against her earthy talk. She took an African primitive sculpture from a shelf behind her and blatantly stroked its carved erection. "But you forget it because the real dead don't get it up like this little toy here. Do you like it? Hermann said it was real nineteenth-century. He check it just before we leave, so no switcheroo."

"María is understandably frightened," Gannon said. "And she does not mean to be so rude."

María shrugged and put the fertility god back on the shelf.

There was a buzz on my arm. Danno wanted me for something. I touched the patch twice, meaning later. Danno buzzed louder.

"Excuse me a minute," I told Gannon and María, and stepped out of the door of the Sánchez suite onto the small balcony. It was late morning outside; the light of the tiny, brilliant Sun was, after passing through the deceptively transparent station wall, just less than a hundredth as bright as seen from Earth, but the scene was still lit much brighter than most artificially lit rooms. The rings of Saturn dominated the view, stretching now almost a quarter of the distance from horizon to horizon as they tilted like a cosmic minute hand with the station's rotation.

This was the problem with Saturn High Station; when you should be tending to business, you're staring at Saturn. I tore my eyes from the horizon and looked at my wrist; the telltales gave me a security confidence of about 87%, as good as you get in this day and age.

"Go ahead," I said

"Hector Sánchez was originally

trained as a physician," Danno told me. "And he's missing."

I was digesting that when the first dart hit me. What you're supposed to do is yank the thing out immediately before it gets to deliver its full dose; but when you're surprised like that—it feels like getting slugged by a bumblebee—you just stand there trying to tell yourself that this isn't really what's happening. So the next one hit me, too.

Finally, some kind of survival instinct kicked in and I slammed a foot against the fake rock wall of the walkway and scooted sideways. I don't remember falling or getting hit by a third dart. But my last thought was that if these were standard rounds, three are generally fatal.

Gannon's face loomed over me and I thought, crap, he's going to give me last rites. But instead, he motioned to his side and Chaplain Dimundi joined him—the first time I'd seen him in person. He was a small, dark, intense man, but with ready smile and a twinkle in his eye.

"Can you feel that?" he asked.

Whatever "that" was didn't register, and I had a moment of panic as I realized I couldn't feel anything below my neck. I tried to open my mouth and a wave of nausea hit me. Mercifully, I lost consciousness again.

The next thing a remember is someone holding my hand. Feeling again! I opened my eyes and it was María Sánchez. She looked very concerned.

"I can feel that," I said, and managed a smile.

She beamed. "He is awake, Father Gannon."

"By the grace of the Lord! Gwen!"

I began to take notice of my surroundings. I was in an apartment on a deployed sofa bed in a living room, it appeared. Probably the Sánchez place.

"How long?" I asked

"Almost three days now," Gannon said; "we nearly lost you. Danno recog-

nized the emergency, broke electronic security and got me out there almost immediately. Exactly the right move; I had a minidoc, and these robes are more than ceremonial."

He had anticipated violence where I had not, despite all the devil's heads and the sadistically mutilated body back on Earth. My body was coming back; my frustration and anger seemed to have their normal physical consequences.

I had to say something. "Thank you. Any idea of who?"

"Actually, it was 'what.' A fiendish little robot hiding in the flowers. It fried itself after it ran out of ammunition, but there was enough left to get an idea of the thing."

Gwen joined us, looking somewhat haggard and all business.

"I'm sorry, Hart," she said; "I don't seem to have a handle on things."

"Under system direction?" I asked. I looked at Gwen.

She looked sad and worried as I'd ever seen her. "There's no trace I can find. He's too good."

"Aye, and he's probably known about Danno all along," Gannon added. "But there is much worse, I'm afraid. I . . . I wish that I could be of more help, but I should leave you with Gwen now."

He backed away out of my sight and Gwen knelt down beside me. What could be worse . . . Chaos! "Gwen, not Kate, tell me he didn't get Kate!"

Tears ran down her cheeks. "Hart, we thought we'd found a utopia out here, where we could live freely, study and learn without being sucked into all the greed, ambition and hatred from which we were born. I'm sorry, I'm so sorry. It happened outside my rooms, robot darts again. It was minutes before anyone got to her. They, they are doing what they can, but her brain has shut down. She managed a message before . . . When you're strong enough."

I was still too weak to sit up. All I could say was "Kate, oh Kate."

I shut my eyes and my memory went

to lying in bed with her, not making love, but just lying there warm and secure in each other's arms. I must have fallen asleep then, because the dream became real and when I woke again I tried very hard to convince myself that María Sánchez' apartment was the dream and that I would wake up and Kate would be with me again.

When I awoke again, it was dark and I was alone. I tried to sit up, but my gut ached.

"Not yet," Danno said, softly enough not to wake others. "You should give your muscles another day to recover from the toxin."

I thought about Kate again and willed myself to sleep to dream about her.

It was still dark when I found myself conscious again in a Universe without Kate.

"Danno, tell me about Kate," I said. "Do you have a download from Danno-2 yet?"

"Yes. Is this wise?"

Psychologically, probably not. But she might have seen something, had some last message that would save someone else's life. "I can handle it."

Kate's voice came on, already slurred by the poison advancing through her body. "Hart, autogun in the garden box across the walk. Can't be connected, can't be . . . love you . . . don't . . . give up . . . on . . . me . . ."

"I love you too, kid." She hadn't made it, but the closure let me cry and the darkness let me do it in private. After half an hour of misery, I started to pull myself together. There were things that would have to be done. I had to do things instead of lie here and stew. "Where is she, Danno?"

"Her body is in the Hyperion dome cryonics facility. The arrangements will wait for your return."

"They'll have to because I'm not going home until I get the bastard." Or maybe ever. Our home would never be the same. I tried to go back to sleep and dream it hadn't happened again.

Morning came and I thought about Gwen, who would be taking it just as hard as I. I felt stiff and aching, but not disabled with pain, and was able to sit up without getting sick. María Sánchez saw me, asked me to sit still for a moment and scurried off to bring me some tea, no doubt loaded with what Danno thought I should have.

"Thanks," I said when she came back. I sniffed it, brought it up to my lips, and hesitated, conscious that I hadn't eliminated any suspects for certain, including María. I pretended to sip.

"Hermann brought it when he heard what happened, and Danno had me let the minidoc sample it and put some medicine in. Hermann should watch out, they'll get him too!"

"Yeah, anyone associated with this investigation is in mortal danger, it seems. Is Gannon up?"

"He had to head for the docks, something to do with the investigations. Gwen is out helping look for autoguns. Do you know she has everyone looking for autoguns because she says we can't trust the computer system? Someone found one outside our art shop and got shot, but they make everyone have an antidote patch first, so she'll be OK. They block all traffic in and out of the station and the media they were going crazy until they pulled the plug!"

I looked at her, speechless. This was a side of Gwen Chryse I hadn't seen; though she certainly wasn't a shy person, she was typically removed and otherworldly. But she also had one of the most brilliant minds in Solar System, and here she had recognized when something had to be done. Who else around Saturn could possibly have asked ordinary people to risk their lives in that way?

"Thank you, María. I should talk to the station manager." Aubin LeTalon would be taking this all in stride, I was sure, but he'd appreciate knowing I was OK. LeTalon was as thin and sharp as his

name suggested, but had a sort of engaging smile and offhand boyish manner that set anyone at ease. I'd known him since he came to the Saturn system ten years ago, and had worked with him on many cases. Not trusting what would happen when we used the comm system, I placed one of Danno's video pickups where it could see the screen.

"Mr. O'Reilly," María said, "they really pull the plug! No power, no computer, no virus. All my appliances are on their backups. Our only light is through the window and the skylight. We are all alone together."

She sat next to me, her thigh touching mine, and looked into my face with the most soulful brown eyes I have ever seen on a non-K-9. "So your wife is dead and my husband has vanished."

I could not help touching her, just to comfort her, and then she sighed and melted into me, her robe falling off her right shoulder as she did so. She made no effort to replace it, but rather reached between my legs with her hand and sealed my lips with hers before I could start to protest.

I might as well have tried to protest a hurricane. Between my awakened physical desire and my pity for her, I could not resist giving her what she wanted. She straddled me there on the couch and took it, cradling my head between her breasts as she thrust herself over me.

Afterwards, she smiled, rearranged her robes and went to reheat my tea.

Data point: no, she was not particularly beautiful, but I could not believe any human male could resist María Sánchez' needs, nor María Sánchez resist vamping any human male. Even Gannon's dry Austrian assistant . . . Edelsohn, I remembered . . . she'd even called him 'Hermann.'

In a fit of self-loathing, I decided I had to get to work. "María," I said. "I need to talk to the Station Manager, Aubin LeTalon."

Her eyes went wide and she looked

around. "To talk to Aubin, you will have to send him a note. Here." She found a pad of paper and a mechanical pencil that might have last seen use a century ago, and handed them to me. I jotted down, "Aubin. Better—need to talk to you. Hart" and handed it to her. She opened the door manually, whistled, and waited. In a moment, a young man wearing power-assisted wings dropped from the sky, took the message, and flew away, momentarily silhouetted against the globe of Saturn and framed by the door. I blinked and the strange picture was gone.

Fifteen minutes later there was a knock on the door. I found my dart gun, motioned for María to release the lock and slide the door aside.

We were greeted by another of the stranger sights in my law enforcement career—a man in walking shorts and a knit shirt with his head in a vacuum helmet. After that heart-stopping moment, I saw the name on the helmet—LeTalon—and realized that, with all the com down, he must be using the helmet radio for communications. He came in, pulled it off, and took my hand.

I managed to shake his hand, but had to sit down again right away—that one minuscule effort had left me exhausted.

The manager looked very grim. "I don't know what to say, Hart. Gwen's been working miracles with the people. We've found three of those things, all the hard way, but nobody's giving up or complaining, residents or visitors. We think we can run this place for a while without computers if we have to. There's volunteer security at every access point, and teams roving their neighborhoods."

Saturn High Station is a small town; push the wrong buttons and it can dissolve into a shouting squabbling mass. Push the right buttons, and its population becomes a single organism with a single will. Gwen, apparently, had pushed the right buttons.

"Thank Gwen and Father Gannon. Don't you find it amazing how two people who don't agree on anything of cosmic importance can work so well together on details and seem so much alike in what they do?"

I shook my head—carefully; it was beginning to pound. "I'm not going to figure that one out in this condition. How are the casualties?"

"Two not as bad as you've been. The exceptions are a girl whose antidote patch came off when she tried to yank a dart out, and her mother who tried to take her own off to give to her child and got the job half done. They're in intensive care."

"Let Gwen know when they're conscious, would you? She'll want to be there."

He nodded. "We need to get this bastard."

"Yeah. Can I get another download from our standalone system on Hyperion? It's a twin of this one, and we'd be secure for at least the time needed for the download. Kate might have left more clues."

Aubin thought for a minute. "Hyperion's easy enough to see from here, so we can point the antenna manually and power the transmitter without starting the computer system. On this end . . . I think we can isolate this module from the bus and power it separately, so you can use the screen. I'll get a team on it."

Saturn High Station was one of the last places built to be serviced by human beings as well as robots and motiles. I had a hunch that after this, there would be some retrofitting of the newer habitats. While we were waiting, Aubin briefed me on their efforts.

"I don't know how long we can keep it up on human labor alone," he finished. "But the best guess is on the order of a week, and my staff thinks they can have a sterilized rump system up in another day to offload the trickiest stuff—like managing the counterweight tether vibration modes." He held up a

hand. "I know what you're going to say; we'll engineer a passive damping system as soon as we get our heads above water."

I gave him a weak smile.

The lights went on. Aubin checked his helmet and nodded. I turned to the comm window in Maria's wall. "Hyperion, this is Hartigan O'Reilly. Do you read?"

After an uncomfortable delay which could only partly be explained by light-speed, I saw the welcome face of Jack Arabian, who comes out of retirement to handle security at Hyperion when I'm away. "Hart, it's good to see you up and I can't tell you how sorry we all are about Kate. As you can guess we've gone pretty much manual control out here as well. I . . ."

Jack's face vanished and the all too familiar devil's head glowed red among flames in Maria's comm window. Maria screamed and hid her hands. It laughed, then moved aside to show Kate, hung on a meat hook, raw and bleeding, being consumed by flames. Then I saw myself float in to join her. The devil's expression turned ugly. "Give it up, Gannon," it said, then vanished in a puff of virtual smoke. Aubin stood mute, his jaw tight and fists clenched with nothing to hit.

Jack looked shocked.

"Did you see it, too?" I asked when my wits returned.

In ten seconds, he answered. "I saw your face, Hart. What happened?"

"Jack, this is Aubin. Hart just saw himself in an image of hell, or this sick bastard's idea of it anyway, along with an image of Kate, mangled and burning."

"I'm OK. It's another fake," I said, to myself as much as to them. "Like everything else."

Ten seconds. Jack nodded. "I'll connect you to your standalone in Gwen's place." He turned around and grabbed a couple of optical cables with standard connectors and mated them. "One of Kate's contingency plans."

My screen went dark.

"Hart, love." It was Kate's voice again. "Something awful has happened; I was ambushed by an autogun and didn't get the antidote in time. But I wasn't ready to die, and this my way of cheating it. I need you to take my word for a couple of things. The first is that this *is* me. I have all of my memories, all my feelings—emulated yes—but I am an independent thinking, feeling being." She appeared as a hologram in Maria's data window.

I sat and stared. Chaos be damned, what was I dealing with now?

Maria moaned, covered her face in her hands and rocked back and forth.

The holo image of Kate continued. "The second thing is that, and I don't know how to prove this to you, I'm not a creation of the madman that put me here. So don't give up on me, please!" The image of her waited patiently for my reply and I could see its chest move up and down, in perfect imitation of life. Think, I told myself. Think fast and good. Kate. Contingency plans. "Danno-2, wipe that file completely, now!"

Ten seconds later, "Kate" vanished. My heart went to my throat; I had almost hoped that wouldn't succeed.

"Done," Danno-2 said.

"OK," I said, trembling. "Now show me the room through a motile's eyes, and let's find and reload the hard copy."

After the maddening lightspeed delay, the perspective changed and I was looking at the inside of Gwen's spare, empty, main room. Where did she keep her data wands?

The image changed. The motile held a data wand in front of its cameras and walked over to the box that held Danno. "I don't have to *find* the hard copy. I have it right here. Should I load?"

I looked at Aubin, then Jack. They nodded. "Yes."

It took about a minute, then Kate smiled at me again. "Danno told me what happened. Good thinking, love. Are we OK now?"

I shut my eyes. "No, we're not OK. I'm sorry, but I need time to deal with this. I need Gwen to check this out. And if it's all the way you say it is, I'm really sorry."

I wiped my eyes. With the voice and the mannerisms, it was impossible for me not to think of this electronic being as Kate. Maybe, I thought crazily, she really wasn't dead and this really was her, but she was pretending to be a computer being in some kind of elaborate hoax to trap our quarry. I wanted to believe and, really, what was at stake if I was wrong? A phony relic? A storehouse of lies of a religion of superstitious fools I didn't give a damn for? What was the worst case against the possibility?

Or could the blackmailing bastard blow up the whole station?

Kate's image developed tears, too. "I understand. I want to hold you and I don't have any arms. Somehow, I'm going to get a body back and make this up to you. Just please don't give up on me now. I have a suggestion. Let me—a copy of me—go into the main frame down there and look for the perp, or his agent."

I thought a moment. How could that hurt? If she were the perp in disguise, it was already there. Otherwise, her intelligent, self-directed program probably beat to hell every other agent ever devised, even Gwen's. Maybe. Then I had the brilliant thought; it wasn't my decision.

"If it's OK with Aubin," I said. "Let's try it."

Aubin nodded. "We have to bring the system up again. After that, it will only take a few seconds. In the meantime . . . Hart, I'm sorry, but I have to call her Kate—I don't know what else to call her. Kate, can you keep the system away from him?"

One can, I guess, accommodate to anything—even talking business with ghosts. It was a good question, I thought. But could we believe the answer?

"I don't think I have to. He's not here, not on this system. I can't detect anything; even those devils that keep popping up and vanishing without a trace. I created a little cybernetic black hole for myself; data in, nothing out, in case he came back. Nothing." Kate's image sighed. "As usual, Gwen's ahead of us. The guns weren't controlled by link; the system here was already down when I got shot."

"Agreed, then. We shall try it. But I think that we must have to keep a hand on the switch for a while." Aubin picked up his vacuum helmet and passed the instructions through its radio.

Kate vanished and reappeared on the screen in the Sánchez living room. "I'm here, and the system seems clean. I'm getting Gwen up to speed—I don't know how to describe this to you, but I'm fully conscious of everything I'm doing, talking to Gwen, the staff, the system, you; all the memories come in parallel and it's not a problem. I can think about literally millions of things at once. There's no sign of tampering on this system. Either he's lying very low, or he's not here. He seems to be toying with us."

Nothing comes easy, I thought. "Yeah, he ignores what we're doing forever, but then suddenly, up pops the devil at some random, out-of-the-blue time."

She nodded. "It's like white noise to disguise something else."

"That's the guy's m.o." I said. "Lots of noise to keep you from seeing the signal. Poor Zapata all cut up to disguise the missing thumb. Devils that pop up to keep people stirred up. Autonomous guns that commit random murders. Kate, we need some bait."

"It's on its way."

"Good. Now, just how much," I asked, "does it take to make one of those devils?"

"He has to monitor where we are and then route it to the right screen, all without being detected or leaving the slightest trace. That's a big AI program."

"Actually," I said, "I was thinking of just the devil image itself. Suppose you didn't care when you delivered it?"

Kate looked puzzled. "But the holo's just trivial clip art, compared to the delivery. If you just routed it randomly, there'd be almost no other code to spot . . . one link to a directory . . ."

"That was what I thought. Danno," I asked, "could you duplicate that devil on the wall screen?"

"I'd need a link to your wall screen, but then it would be easy. There's a maintenance panel below the screen; just put your hand on it and say 'release.' Then unplug the optical cable third from the right and point the stub in my general direction."

"Oh, chaos!" Kate exclaimed. "That's OK, Hart, I've got the picture."

"What picture? I was going to do an experiment to see what a devil module code looks like, to help your search. I thought it was kind of clever."

"I'm sorry, Hart, it was. But if I'm right, it won't be necessary. I've had a one track mind—even with this gazillion-hexaflop computer for a brain. I, who color outside the lines for a living, have been just assuming the only way to do the things we've seen is to take total control over the big systems. Hart, that devil's head could fit in a chip almost too small for us to see—too small to block a standard optical data cable, but not too small to add something to it, in phase, in sync and everything. If someone stuck a chip like that in the optical connection for a wall screen or a door screen . . . Hart, let's look at that cable."

I pushed myself up to go to the wall panel and my legs buckled and I settled back down again. My mind may have forgotten what had happened to me, but not my body.

"I'll get it," Aubin said and went over to the plain wall, released the panel, and disconnected the cable.

The flash and the pop caught us all by surprise. María screamed.

"Damn!" Aubin wiped soot from his

face. "No need for all the fancy security now, I guess. A chip—it is gone now but it was there—probably fries itself when caught." He showed us a tiny black spot on the end of the cable. "So that and the guns were all noise, to make us think he was running the computer systems. So we shoot ourselves in the foot by shutting down."

I pursed my lips. "We've been looking for a world-class cyberneticist, but right now I'd guess we need more of an engineer; someone who's an outstanding tinkerer—someone who really knows materials and standalone gadgets."

"If we assume," Kate said, "the perpetrator was physically on Earth in Rome when the original crimes were committed and is now on Saturn Station, there are seven people who meet those criteria—three passengers, and two crew members besides Father Gannon and Father Dimundi . . . oh, shit. Smart Mobiles. Bugs! Hart . . ."

I caught the motion of the door out of the corner of my eye. "Take cover!" I tried to get up to grab María Sánchez but began to fall before I could reach her. By sheer effort of will, I made myself fall behind the couch. María was bending down to help me when the device hit the floor with a soft metallic clink that I will remember through whatever remains of my life. I don't remember the blast.

When my eyes cleared, I was looking at Gwen and Gannon. Gwen looked every one of her sixty-some years and Gannon as worried as I'd seen him.

Gwen put a hand to my lips when I tried to open my mouth. "Two days, this time, Hart—a severe concussion. The doctors insisted on the down time. The good news is that you've completely recovered from the poison, and should be up and around again in a few hours."

Gannon's eyes twinkled for a moment. "You'll probably object, but some might even see it as a miracle. I'll take it as such, for I'm praying for another and

need to believe it possible."

María Sánchez. Memory slowly came back—she'd been more exposed to the blast than I.

"María Sánchez," Gwen said as if she had read the concern on my face. "She's in critical condition. Her face and shoulders were behind the couch when it went off. The rest is a reconstruction job."

"Gannon," I said. "I'm sorry."

"It is harder on me than it should be, and I deserve that, I suppose. They say she'll make it if she wants to enough. We've shown our replica to everyone on Kate's list. No one bit. You need to go back to sleep again."

"What about Aubin?"

Gannon shook his head sadly.

"Gannon, I have to trust you." At least I had to say I did. "But I'm starting to think that whoever is doing this is entirely to close too us. If you haven't already, check out your chaplain. Thoroughly."

"Impossible."

"Check him out. This is no time for faith."

Gannon looked angry for a moment, then nodded. "We have to wait for a while. Except for standalones, they've shut everything down here and at Hyperion; they'll be using standalones for four days now while they check every connection they can get to." Then he smiled ironically. "An exorcism, if you like, and I found some old words to go with it, to aid the process. To what effect, I dunno. But it made me feel a might more useful than I've been, lately. Much as it may pain my heart, I shall look objectively at Chaplain Dimundi."

Five days later, I was functional again, but María Sánchez was still on life support and both Hector Sánchez and Chaplain Dimundi were missing. Mei-Li Wu, the station council secretary, had taken over when the vice-chairman had resigned rather than move up into the crossfire. I can't say that I blamed him,

but Mei Li made a point of standing up in the open with Gannon, Gwen, and me to declare her determination to end the siege and pleading with everyone to redouble their efforts to capture the bomber.

Incredibly, nobody had seen anyone suspicious near our door at the time the bomb went off.

Back in our thoroughly swept quarters, we met in the small living room of our suite trying to figure out which end was up with the aid of Kate's cybernetic ghost.

She apologized for her limitations. "I was too careful, put too many checks on my cybernetic self. I made this virtual room for myself, which I experience pretty much like any room I had when I was alive, except it doesn't have any doors. My interface with the system works pretty much the same way, too, except a lot faster. But I have to operate through it, and all the blocks and limits still apply. I can't spy. I can't get into privileged data bases. I can't use motiles on my own volition. I can't get the system to evade Asimovian constraints, though I think I could if I could operate independently of it. And I can't reprogram this mess from inside the box I made for myself."

"Would you want to?" Gannon asked.

"What if we have to harm someone to recover your relic?" Kate replied.

Gannon frowned and looked at Gwen. "If we have to violate people's rights, I would rather we do it ourselves. Hart, I asked Oporto about bugs in mobiles. He swore he'd never done a thing like that, but . . ."

"But what?" If Dimundi had been bugging everyone he gave a mobile to all along, he'd have a wealth of insight to bring to his ministrations, no doubt. I remembered the swarthy man's smile and found my judgment of its sincerity depended on the context of my thoughts. One more for Gwen.

Gannon pulled a small mobile with a shiny Saturn and moons from his pock-

et. "There's always a first time, and this is an emergency."

"Damnit, Gannon, he's a suspect."

Gannon looked sad. "So far, I admit, he's been everywhere the devils have popped up, but apparently done nothing amiss. We can watch what he does with what he learns from these."

"If I'm freed from the constraints, I can watch." Kate said. "There are motiles under system direction all over. But only twice in our history has someone been able to direct those motiles to assist in active physical interference with the actions of a human being. There are redundancies, checks and alarms so you have to understand the philosophy of the Asimovian rules and how they are constructed, as well as being able to influence the source code."

"Now who might it be that was able to accomplish that?" Gannon asked.

I nodded to Gwen, who smiled.

"The first time," I told him, "was to save my life."

Gannon ran a hand over his thinning hair. "Then, if I understand how this works, it seems it may be somewhat easier to apprehend the killer than recover the relic."

I nodded. "For something . . . or someone . . . operating under Asimov's rules, the threat to human life is paramount. I think its time to start showing our reproductions around and noting reactions."

"Perhaps," Gannon said with a smile, "we should check it ourselves first. As a wee calibration of how good a forgery you have made?"

It didn't pass. Edelson pursed his lips and took from its case an odd piece of equipment that resembled a white plastic trombone with a thermos bottle instead of a mouthpiece.

"We shall see," he said.

"How does that thing work?"

"In this bottle are a few billion antiprotons. The tubes are a folded three-meter accelerator to push them fast enough to penetrate several centimeters

of material." He pointed to the center of the "bell." "The billion or so antiprotons that rush forth from here release enough energy that, if it were light, might be visible to the unaided eye in a very dark cave. But it does not make light; it makes x-rays, gamma rays, and annihilation products—not enough to worry about, I assure you—that come back to the spectral analyzer." He placed the box against the "bell" of the device and looked at a screen mounted on the plumbing.

Edelson frowned. "Very good."

"What did you find?" I asked.

"Zirconium-90."

"Huh?"

"Another demon from long ago. For a decade or so during the twentieth-century struggle against totalitarianism, uncontained explosive nuclear reactions took place in the Earth's atmosphere. These put a radioactive isotope, strontium-90, in the atmosphere. Because it resembles calcium, it got into milk and hence into milk-derived products, including the glue that held Saint Teresa's box together. Zirconium-90 is what happens after a strontium-90 nucleus rids itself of a couple of electrons to make itself stable. I am surprised to see it here."

"Why?" I asked.

"Because," Kate's image said from the screen, "it wasn't in the data he gave us."

"And that was not the only thing," Edelson clucked, waving a finger. "But it is the only thing I will tell you, since you already know it. You have a replicator and so do others. The only hope we have to ensure authenticity is to hold back some information from these promiscuous data bases."

"But," Edelson continued with a shrug, "your replica will certainly fool all but the most sophisticated people interested in such things."

"Than you, Mr. Edelson," Gannon said. "We shall see about Hector Sánchez."

In the next three days, we inter-

viewed everyone who traveled with the Sanchez's on their flight from Earth. No one recognized the relic, let alone showed any emotion on seeing it.

Late in the evening of the third day, Gannon, Gwen, and I had a sip of the Bushmill's again, to dilute the frustration a little. Kate created some virtual Bushmill's for herself. Then the rest of us said good night to Gannon. Gwen and I collapsed on our beds as Kate continued to follow what leads she could.

I rose again near midnight, unable to sleep, unable to concentrate, and decided to take a look at full Saturn making its stately rotation in our sky. With no one looking, I reached up and, as if playing Atlas, held my hands in front of my eyes as if I were holding the whole huge globe. The whole world in my hands. Hands. Fingers. Scars. When it hit me, I shivered; why hadn't I thought of it before? Motive? Nothing majorly obvious. Gadgets? Dimundi made those too. But . . . Hermann she'd called him. Everyone else called him Edelsohn. I rushed back inside.

"Edelsohn." I said. "Kate, get me a recent video of him. Magnify his hands."

"Chaos!" she said. "Of course. You're right."

She could look in milliseconds, but I needed to see for myself. The image of those well-used hands filled the screen. Well-used hands that had done things to give them little scars from nicks and burns. Noise to hide a surgical scar.

"The left thumb," I said. "Slow motion as he moves the hand."

Around the left thumb was a thin pink line, as perfectly healed as any minidoc with a surgical module would leave it, but not healed long enough for the color of the new skin at the joint to match the pigmentation of the rest of the hand.

"The scar around his thumb. It could, of course, be a coincidence."

"Or a doctored image, depending on how thorough our adversary is," I conjectured.

Kate shook her head. "No, not doc-

tored. Too much data and no fuzzy-bit evidence."

"Danno, where is Edelsohn?" Danno had fewer restrictions than Kate.

There was a longer than usual wait; seconds instead of milliseconds.

"He cannot be located. Last seen around the docks."

"Get Gannon up here."

"Get Gwen up," Kate said.

I stared at her.

"This is a lot more important to her than sleep; trust me. I can do it but you need to authorize it."

"Huh?"

"I tried to tell you. As far as this thing is concerned, I'm just another program. I'm not a person and it doesn't inconvenience people on my account."

"Yes, do it. I'm sorry, Kate." I had gradually began to think of her as Kate; how dangerous that would be to me, I had no idea. She wanted to hug me and had no arms. I wanted to kiss her and cradle her, and she had no body to touch.

Gwen darted into the room, eyes wide.

"Motive?" she asked. Kate had already briefed her through the coronet.

I shrugged. "The Vatican files contain the secret information needed to authenticate and thus duplicate every work of art and saintly relic the Vatican still owns. Edelsohn, of all people, would know what to do with that information. Or maybe he's involved in the politics somehow."

Gannon came in trying to shake sleep out of his head. "And what might it be now at this time of night?"

"Edelsohn. Look at his thumb."

Gannon went white. Then he asked for some time by himself and went to the bathroom.

In a couple of minutes, I came to my senses and got up to go after him.

Hell, he might have been in on it; this whole manhunt might have been a charade and all I'd need was a suicide. Gwen grabbed me and shook her head.

Trust me, that hand said, so clearly that I have to play the record to prove to myself that she didn't say it out loud. For all her craziness, when it counted, I trusted her.

Gannon came back limp and sweating like he'd just run a marathon. "I . . . I . . ." He took a breath and started over. "I may have badly misjudged things. My apologies. You are, of course, authorized to do whatever you need to do to apprehend Edelsohn, and will have my full cooperation and that of the church."

I stifled the uncharitable thought that this cooperation didn't mean all that much ten times Earth's distance from the Sun.

"Danno, Does Edelsohn know we suspect him?"

"Possibly. Dimundi's bug has been disabled."

I shot a look at Gannon.

"I hung it in our room," he said. "So that you might be sure of me, at least."

"Edelsohn probably found it right away," I said, "and assumed it was directed at him."

Gannon looked miserable and nodded. "We'd better warn Oporto."

Of course.

"No one home," Kate said.

Kate's image was blocked out and the devil appeared, then its red face slowly morphed into a renaissance-inspired image of a winged angel with a horn and Edelsohn's face. The angel lifted its horn and blew taps. There was an ironic fitness to that; I had not suspected Edelsohn of a sense of humor, either, but now everything was in the open.

Gwen put a hand on my arm. "Pre-programmed response to a verbal logic set—it would fit on a microbot. It would just sit there in the optical stream until we said something about Edelsohn being suspected of the crime." She thought a minute. "We should assume he's got bugs like that strewn throughout the optical system by now, tapping communications and probably multiplexing them on through to his own

standalone somewhere, disguised as noise. Chaos! They should leave a trace, an impedance in the optical links; nothing one would see in digital but the maintenance program will be looking at analog signal strength . . . Kate?"

There was actually a hesitation. "I've found a hundred and seventeen. He was busy."

I thought for a moment. "Enough monkeying around. We're not going to finesse or trick him. We've got the main system and some twelve thousand scared and inconvenienced residents of Saturn High Station versus him and his random bugs and booby traps. Let's pick him up. Get everyone and everything on it; full court press. Rip out the chips, whack the weeds. We may take some more casualties, but I think the harder and faster we work, the fewer there will be. Danno, get Mei-Li Wu and the council up and ask for emergency powers. Gwen, can you get Kate free from the Asimovian restrictions?" Why had I hesitated, I wondered. How much time had that cost us?

She pointed to her coronet and was silent for a moment. "With Mei-Li's consent . . . she's still a little groggy . . . it's done."

"Meanwhile, Hector Sánchez is still at large."

"Sánchez checked out a shuttlecraft," Kate said. "I think Edelsohn is probably on it."

"How probably?" Gannon asked, with a tinge of irony in his voice. Even now, I thought, he needed to make a point of Kate's non-personhood, unintentionally sending daggers into my heart. I shot a look at him, but our eyes didn't make contact.

I would have given anything for a hint of sarcasm in her electronic voice, but Kate answered politely. "The number is currently around zero point eight, but it grows with each new piece of information. The shuttle's base override function has been disabled and we can't take control.

"There is a new demand from Edelsohn; in addition to access to the Vatican data base, he wants free passage to the asteroid belt."

"Can they get there?" Gwen asked.

"Not quickly, but yes. They've got about ten kips with full tanks—that's enough for the hyperbolic excess to drop sunward in about six years and circularize. Maybe four years, if they have friends at perihelion."

"Can we catch them?" I asked.

"Why us?" Kate replied.

Because, I thought, I was a guy and I don't like to lose. But it made sense to turn it over to the inner solar system. "So we let them go and don't give Edelsohn access."

"The shuttle's not going anywhere right now. Maybe they'll talk."

Instant decision time. "Danno, get me a cab and a shuttle." I looked around me and tried to think of something inspiring to say but realized that was wasting time. "Let's go. Kate, take control of the station's main comm laser." At an average power of gigawatts it would make a weapon if needed.

Saturn High Station's volume is eighty-something percent air and when you need to get somewhere quickly, they have ducted fan craft. A buzz at a low b-flat and a whoosh greeted us as we went out the door, the bubble popped open, and we piled in. The thing was designed to pull one gee up on Earth, so here it took off at 1.6 in the station's Mars-normal gravity. We were at the nearest support tube in two minutes. Gannon's eyes went wide as we flew right by the elevator stage and at the spoke base. Two big clamshell doors flew open and we zipped right up the hollow maintenance shaft with a clearance of centimeters on either side. It felt like we were going at the speed of light, but since it took ten seconds to reach the docks, it couldn't have been much more than a hundred meters per second. After the fan cab flipped and flattened us with its deceleration, we were in zero gravity.

Kate had done the check-out by the time we got there. We were through the lock and into the seats in about half a minute, even Gwen, who was as excited as I'd ever seen her.

They saw us coming and their attitude jets flared.

"Crap," I said. The other shuttle had gone into a flat spin, ending up with a period of about five seconds. There's no good way to board a spinning spacecraft; if it's derelict, you can try to go in at the spin pole, but an unfriendly hand on the controls could induce a wobble at any time that would hit a prospective boarder like a cricket bat. Someone with a strong stomach can wait us out.

"Their lock's opening," Gwen said.

We waited for it to come around again.

Silhouetted in the bright light of the lock was a spacesuited figure with a gun, clinging to the rim of the door to try and stay inside. I couldn't tell what kind of gun, or whether it was tracking us, and didn't wait to find out. "Back off a kilometer," I told our spacecraft.

"May God have mercy," Gannon said, "what do we do now?"

"Right now . . . " Yeah, right, O'Reilly. What? "Right now let's wait and think. Get your shipsuits on and helmets handy."

The spacecraft coasted out from the station a kilometer apart at a few meters per second. Our shuttle had standard shipsuits, and we all scrambled into them quickly as possible, with Gwen maybe savoring an extra few seconds of her kind of freedom in transition. I caught Gannon stealing a wistful glance and looking away with a guilt that was, in Gwen's case, completely unnecessary.

I felt the smart fibers of my suit mold themselves to my skin as my body heat activated it and made a few adjustments. Some standard coveralls went over that; their name tag displayed my name as soon as I touched them and their color stayed a neutral gray. Gannon's, I noted,

went to black, and Gwen's to a dusty red.

"Think Edelsohn's monitoring com? Gannon, you want to have a try?"

The priest nodded and took a breath. "Hermann and Hector, we have plenty of time. What is troubling you so much that you would do this? Will you talk, at least? Help us understand."

A tone indicated Edelsohn's shuttle was about to respond.

On our screen, Kate's image was replaced by Edelsohn's image among flames.

"This," he said. "is what I have to look forward to, though I hope for a martyr's forgiveness. Father Gannon, someone has to reverse the course of our decay; I have decided to bear the burden of the sins needed to make that change. I will take the greatest sin unto myself so that others who are without sin may inherit Christendom. I know who most of the cardinals favor and that man must never be bishop of Rome. I serve a greater cause than mere law, and have hopes of being forgiven."

What others, I thought. Then, did it matter?

"Hermann," Gannon said. "You are not serving the greatest cause. For the sake of your soul, come to your senses."

A grim look passed over Edelsohn's face. "We must do what we must do. Now, if I do not get the access, I will aim this shuttle at the tether and ram. It will indeed break; I've modeled it and there's gigajoules of tension. The stump will whip back to the station. There is nothing that can stop it. Many people will be hurt and the relic will be lost forever. Your end will experience about twelve gravities for a few seconds; it should fall apart. You must believe that I am at peace with doing this. The end of my life is before me and glory or suffering awaits; but I have no fear. You must meet my demands now."

"Kate, secure," I said. Edelsohn should not hear what I had to say next.

She nodded.

"Get the station main communications laser ready to focus on his drive bell. If he kills that spin to try to maneuver we stand a good chance of disabling him. Danno, keep this shuttle between him and the tether core. Everyone, helmets on, strap in for collision."

Gannon looked up with his mouth open. I watched thought replace fear on the man's face. He turned to Gwen, then to me, then smiled as if he'd just figured out he was on the winning side.

"Please pardon my foolishness. Hermann?" He waited a moment for the link to resume.

"What is your answer?"

"Why hurt people?"

"I would rather not, but if it happens, well, suffering is good, Father Gannon. It improves the soul and shows worthiness for the life beyond. It cleanses us. Some of us have forgotten that." Edelsohn unsealed the front of his shirt. His chest was covered with scars, some still red and raw, others ancient and white. "I have not."

Gannon's lips went as tight with anger as I'd ever seen. But he said nothing.

"By the way," Edelsohn said. "I can maneuver while spinning; it just takes a little longer."

His image jerked back for a second.

"He just pulsed his main drive," Kate said, "when it pointed the right way. Three gees for a second. He's gone from eight meters per second negative to almost twenty positive."

The laser wouldn't have time enough to do much while he was in spin. I looked to Gwen.

Quickly, Gwen pulled Gannon over to her and whispered in his ear.

Gannon nodded to Gwen. "Very well. I authorize the transmission of my access codes to the shuttle. Do what you will. The Church will survive. These people will survive."

He sighed heavily. "Now, Hermann, please, where is the relic?"

Gwen smiled like I hadn't seen her

smile in days and touched the interface coronet under her long, flowing hair. Back on her game, she was, with every cybernetic system in the Saturn system in the palm of her mental hands. And, I reminded myself, the controls were off. I looked at Gannon, who shrugged. There were gods and then there were gods.

"I will tell you when I am safe away," Edelsohn answered, "and my mission is accomplished. Some three hours from now. For now, out."

Kate said, "He's sent his request. Round trip to Earth is 171 minutes today."

"I'm sorry," I said. "Normally we don't yield to this kind of extortion."

"We didn't, exactly," Gwen said with a smile. "His data stream included a parasite instruction that will put a marker in any data requested with that access code."

"We suspect," Gannon added, "that there are others on Earth who will use that data. Letting them have it is the only way we'll find out who he's working with back on Earth, and if we do not find that out, I fear they will succeed one way or the other." He sighed. "We are fighting an ancient battle, Hermann and I—on one side is the sternness and discipline, on the other hope and compassion, and none of us knowin' for sure which side the Christ is on until the hereafter. And we'll be fighting that battle 'till there be nothing left of us but scraps of history. I'm sorry to involve others."

He closed his eyes and I thought I saw the hint of a tear. "But there are rules to this fight, and they are being broken. Knowing who is doing this is more important than any damage they can do."

Gwen put a hand on him. "I'll loan you a copy of Null, if you like. She'll hold off the devils."

Gannon smiled and shook his head. "But your fledgling would be getting projects of her own, now, wouldn't she? Even I know we're not ready for that yet.

Another century or two; perhaps. Kate, Hart, for what it's worth I believe an immortal soul is an immortal soul whether we can talk to it or not. There's no question in my heart that you're at least an aspect of yours, Kate, and I apologize for my incivility. God has allowed you this and we must accept that judgment. So now tell me, what is it like?"

Kate smiled politely. "As far as I can tell, I'm me."

Gannon, Kate, and Gwen discussed the nature of existence while I busied myself with trying to reconstruct Edelsohn's movements throughout the Saturn system and correlate them with the reported activities of his various devilish mechanisms. Like most things, it wasn't clean—inevitably some people had found the temptation to get in on the publicity too much and had invented an Edelsohn device report to make. Then there were copycats—probably the work of second-year electronics students who thought it was cool to tease female targets with erotic images. So I had more Edelsohn device reports to sift through than Edelsohn himself could possibly have been responsible for if he'd been a permanent resident.

I was busy enough that Kate's announcement of a return data stream to Edelsohn caught me not watching a clock, but rather linking the movements of a troublesome teenager to the location of an apocryphal Edelsohn device.

"For what it's worth," she added, "I've used the station radio telescope to pick up biomed telemetry. He's got the transmitter off, but he's close enough that I can pull its exciter out of the noise when the shuttle's windows rotate into line-of-sight. That tells me there's only one person aboard; one breathing sound, one bio-ELF source."

"Edelsohn?" I asked.

"Fifty percent," she said. "We see Edelsohn, but it could be a sim. Sánchez should be controlling the shuttle, but Edelsohn could rig his way around that. Oh, Gannon, there's also a message

from your superiors. It looks like the tagging worked."

Gannon smiled. "Bless you." He looked around at the rest of us. "This could still be a frame," he said. "I've known Hermann a long time."

The Kate I knew might have rolled her eyes. This one was more under control. "Also, they found a print in Edelson's office, on a discarded plastic glove. Zapata's thumb, Edelson's index finger."

Gannon's face turned white.

"I'm sorry," I said.

"Not that. Look—the shuttle's maneuvering. They're going to ram us after all. Oh, Holy Mother, with us dead, who will stop his accomplices from using those access codes?"

"I will," Kate said. "He can't kill me twice. But I don't think he's trying that."

We watched its thrusters kill its spin. Then a spacesuit hurtled from a still-open hatch on a trajectory back toward the station. The lights on the other shuttle powered down—abandoned, it would wait for the next human direction. Its course would currently take it back past the dock in an hour or so; the staff would collect it then.

I shook my head. "Not even a good try. He probably thinks we'll let one go while we stay with the shuttle in case the other makes another threat. But we know there was only one person aboard. Danno, Magnify. What do you have?"

"A spacesuit, tumbling toward the station. No data link."

"Rendezvous with that." Our shuttle obeyed and we began to close in on it.

"Wait," Kate said.

"Huh?"

"Trojan horse, booby traps. We should go back to the docks and let the motiles handle him."

She was right, of course. So we were headed back in when the suit started tumbling. We all saw that and suspected what it meant: Edelson had chosen martyrdom instead of capture.

Father Gannon muttered some words under his breath, then turned to me. "We need to recover the body, at least. Well, Hart. It seems to be over."

I nodded in agreement. Tentatively. "Let's suit up. It still might be booby-trapped."

The motiles found no detonators, active electronics, or life of any kind when they got to the space suit. The faceplate was a mask of ice crystals. We pressurized at zero Celsius to preserve the evidence and went to our forensic work, outside in. We thought we had the story, but you follow procedure; the Universe can fool you from time to time. When I opened the casing of the suit's life support module, I found it had not just been turned off; it had been physically removed.

I pointed to that. "He wasn't going to risk changing his mind. Without the fuel cells in the LSM, the batteries run out in twenty minutes, the air goes bad, and you suffocate or freeze."

When the helmet came off, Gannon gasped.

The body inside was that of Father Dimundi.

Gannon floated over to a wall, grasped a stanchion, closed his eyes and prayed, in Latin I suspected because I didn't understand a word of it. Then he turned and floated back to me.

"Not much of a point to kneeling out here, is there?"

It was clear, even to me, that Gannon had been hit hard by all this. "You all right?" I asked.

He shook his head. "I am in need of forgiveness for what I was thinking and saying about poor Hector, and for the trust I put in Edelson."

I shook my head. "Both were reasonable, Gannon. Can't blame yourself. And that still could be Sánchez out there."

"Hart, when you pretend to be connected to something that is above and beyond the reasonable, as I have for all these many years, well . . . I feel . . ."

Put upon, is how I'd put it. I thought of a Biblical reference. "Like that guy, Job?"

He looked at me, surprised, and smiled.

I held up a hand. "Now just hold it there. Education and belief are two different things, Gannon. Whatever else it might be, the Bible is a great piece of Western literature. Now, I'd guess whoever wrote the story of Job had a few days like yours and wanted to pass a message on down."

"Ha! And I'll be guessing you're right on that."

I smiled politely and turned to my work. I could have used a long range p-bar probalyzer, but I was going to have to make do.

There are certain advantages in doing this in zero gravity. You don't have to disturb the corpse much to examine all sides of it, just let it float to the middle of the room and give it a touch of angular momentum. That revealed nothing, so, with Gannon's help, I removed the suit.

Had Edelsohn actively killed him? Or had he just set another trap into which Dimundi had sealed himself? The latter was more Edelsohn's m.o., and there was, in fact, no visible mark on Dimundi once we got his body out of the suit. I found myself working very carefully, worrying as much about what kind of Edelsohn trap I might stumble into as about making my examination.

Then I saw it. "Gannon, the bulge in the left thigh pocket?"

He froze, looked, and nodded. "Hermann was good with gadgets; he might have made a detonator without electronics—a clockwork or a pressure device. Is that what you're thinking?"

"Exactly. We might get a couple bulkhead doors between us and it before we have the motiles take a look. Kate, can you get a motile to that?"

"Got it, Hart," she said. Two of the spider-handed stick figures jetted past us toward the suit and body while we

pulled ourselves through the lock, touched an override button to seal it behind us, then pushed ourselves through next door. As that one thunked shut, Kate asked, "Ready?"

"Ready."

There was no screen in the corridor, so we waited blind for an eternity that must have been less than a minute.

"It's not a bomb," Kate said. "It's either the relic or a damned good copy."

There were several of those about, I recalled. We went back to the dock through hissing doors to see the find.

Out of idle curiosity, or professional thoroughness—take your pick—I opened the box. There was a slip of paper in it. I pulled it out, looked at the others and read:

"María. Hector told me that Edelsohn switched the boxes. I didn't believe him at first, but when he disabled the bug, I followed him here and got it back for you. But he saw me. I'll try to get away in a suit. If not, bless you. Sorry, Oporto."

I took a deep breath and stared at the bulkhead. The relic. Where would the best place to hide it, given that everyone in the known Universe believed it stolen and was looking for it?

Gwen touched my shoulder. "He was already dead when we caught them. There was only one living person on the shuttle."

My mind cleared. "Only one breathing person. Which means that Edelsohn is still there, and probably knows we found his coconspirators. Hector Sánchez is there, too, but in cold sleep, I suspect." But would he flee or ram? "Kate, warn Mei-Li about a possible collision!"

"Impact will be in eleven minutes, if he starts now," Kate said.

An outward calm appeared to descend on Gannon. "Then we have time to be ready."

"He's not trying to ram, not yet," Kate announced. "He's drifted behind the station from the comm laser. His shuttle's

on manual control, of course, and the radio off; I can't get in to override. He's clearing distance, keeping the bulk of the station between him and the laser."

"Escape?" Gannon asked

"And redundancy," I said. "He has more than enough reaction mass to make escape velocity, change course when he's out of view. Then he'd go into hibernation so he looks like any other rock, and coast all the way into the Belt where he can circularize at some random time and then vanish. Eventually he'd fabricate replicas of the things from your database that you won't be able to tell from the originals. Depending on what happens with your politics, there may still be time for blackmail."

"No, after the election, that would be unthinkable," Gannon said, relieved. "The rest we can deal with at a later date. At least we have the relic back."

I thought I knew better, but nodded. I handed him the note. "You should go tell María."

He shook his head, "It would almost have been better for her if Hector had died." He touched the box, lightly. "But seeing this will give her some hope and a little spirit; that's what she needs just now. Until later, then."

Then he grabbed a handhold and pulled himself down the corridor.

"Kate," I said. "As a quick check, where's our replica?"

"Uh, Gannon had it in the room he shared with Edelson . . . but it isn't there now, at least not in plain sight. We can have a motile look."

I nodded. I was now pretty sure it was the one we had, but . . . "For form's sake, check it. Gwen, let's go back to our room."

Sometimes, in a final panic, some of a body's controls let go. The results of poor Father Dimundi's final moments had thawed enough to start to smell.

Kate searched for Hector Sánchez while we mortals treated ourselves to coffee before going back to work. With

the smell of the best beans grown around Saturn in our noses we plopped down on the sofa. Kate joined us on screen, holding her own virtual cup of coffee and smiling. I thought of Edelson, alone, drifting away from the station, worried about maybe getting fried by a laser and maybe looking at a life sentence of dodging authorities through the asteroid belt as a best case.

"I have a surprise for you," Kate said, "when the next shuttle from Hyperion docks in a couple of hours. Meanwhile, any ideas?"

"Do you think Edelson will talk to us? Open a channel, anyway."

"Done."

"Edelson, the game's over. Gannon's access codes won't do you any good six years from now and we have the relic back."

No visual this time. Just his voice.

"Don't be too sure of that."

"You've been playing the old shell game with us. I know where it is and it will only take a few hours to check with the Vatican to prove it. You have no leverage any more. Turn yourself in."

Silence. Bingo on the relic.

"There are others involved. I cannot. Edelson out."

"He's burning," Kate said.

She gave us a visual of blue flame of the rocket against the black limb of Saturn. Something was wrong, very wrong. Orbital motion in most solar system bodies is counterclockwise projected against the plane of the ecliptic, and the Silver Rose is no exception. But . . .

"He's burned his rockets against the direction of our orbital motion; he's inward bound. Kate, we're too far in for a net hyperbolic excess maneuver; where's he going?"

"The ring plane, it appears. He could make the ring plane and steal some more reaction mass."

Gwen's eyes went wide and flicked rapidly between cybernetic vistas that only she could see. I knew enough not to interrupt. Finally she shut her eyes

and lowered her head and raised it again. "His periapsis is below the clouds by now. There's nothing that can reach his vector."

"Just like that. Martyrdom," Kate said.

It took me a minute to figure it out and shake my head. No, he'd fought his furies every step of the way through his life and he was still fighting. But he'd made another miscalculation.

Guilt hit me then. It was a miscalculation I'd led him into, because I couldn't resist boasting.

Gwen looked at me and raised an eyebrow. She knew.

"He killed two people, three now and he would have killed more, Hart. What's done is done."

"What . . . happened?" Kate asked. "I have a gazillion times your RAM and I can't figure it out."

She couldn't? I shook my head. "He couldn't trust a computer under our control, so he had to set up his burn by eye. He got the plane, the time, and the flight path angle about right, but he's from Earth, remember? How does he tell which way he's going? The stars are moving too slowly. So he looks at Saturn; at how the clouds go by."

"It's turning below us. Oh! A sign error!"

"Exactly. Around Earth, you're not revolving faster than the planet rotates until the planet is just a little ball in the sky; in a lower orbit, you are clearly going around the planet faster than its surface, so the clouds and continents disappear behind you. Saturn rotates in about half the time it takes Mimas or Saturn High Station to revolve around the planet, so here they disappear ahead of you. He was in that flat spin so long, I think he got confused about which way was north, and looked to the clouds for help."

Gwen sighed. "You said he went the wrong way, Hart? But is there a better place for him? I wonder. He sought the heavens, but the means he chose led him the other way."

"And the relic?" Kate asked.

I just smiled and finished my coffee. Come to think of it, I really didn't feel that bad about Edelsohn and Sánchez. "Time to go see Gannon and María."

The priest's face lit up when he saw us. "Thank you, thank you," he said and turned to María Sánchez, whose eyes went wide at the sight of the relic. He handed it to her. "Saint Mother Teresa," she whispered, "in the name of Jesus, please help me."

"She will, María," Gannon said. "She will."

María smiled and closed her eyes.

Dr. Darrien whispered, "She needs some sleep," and they left the cubicle.

In the hall, she looked at the readouts by the door. "Adrenalin up a bit . . . she wants to live now. We'll need to watch a few more hours, but I think the crisis may be over."

"I'll wait here until it is," Gannon said.

Dr. Darrien nodded. "There's a waiting room down the hall."

"If I wouldn't be too much trouble, let me stay by the door 'til she has no more need of the relic."

One way or the other, I realized, my partnership with Father Gannon was over; the priest had what he wanted, or at least believed he did.

"Good day, Gannon," I said and started to move away.

"O'Reilly," the priest said, "now aren't you just a little moved by what you've seen?"

Gwen nodded a smiling farewell, turned away so Gannon couldn't see her barely laugh, and headed down the hall, leaving me at the mercy of the priest.

Gannon shrugged and tossed his head a little in her direction as if to say "What would you expect from such a heathen?" then stared me in the eye.

I studied his face. Never had I seen such hope and joy on a person's face; all of a sudden Gannon had been handed an event that could at least be seen to justify his entire life, a miracle that re-

warded all the faith, all the discipline, all the persistence in the face of ridicule. To squash such joy with the truth about the relic was beyond me—anyway there would undoubtedly be those who would say the actual atoms that composed the relic were irrelevant, that it was the faith that mattered and it was that faith that St. Teresa had rewarded. I simply shrugged my shoulders.

"I'll have to think about it," I said.

The priest's smile lit up, if possible, even more, and he took my hand. "Well, now you do that, O'Reilly, and me know what you think. I know you've got to be off now. May the wind be at your back and the Lord be good to you, then."

I smiled, waved, and headed off after Gwen.

Time to wrap this case up. There was one more piece of bad news. Hector Sánchez hadn't been on the shuttle after all. His body turned up in a bag floating in orbit near the station. To no one's great surprise, it was missing a hand; the shuttles have a joystick—a single finger won't unlock one and Sánchez had checked it out. Edelson had not tried to confuse things this time. Maybe he was in a hurry. For whatever reason, the rest of the body was in one piece.

Kate's surprise was there when I opened the door, and it was big one. She was there to greet me—in the flesh. "Well?" she said.

Gwen opened her mouth and shut it, then smiled and said, "Hyperion's Opticor was off-line for five days. But not down, apparently. Congratulations."

Kate nodded, spread her arms and the two women embraced.

"We didn't want to say anything to you two until we knew it had worked," Kate said later. "I'm just like the original, but without the poison and necrosis."

She reached for my arm, tentatively. An army of ancient prejudices about ghouls and zombies tramped through my mind. I had adjusted to her death and her electronic ghost and now I had

to unadjust, quickly. I shivered. But my fear vanished at the first touch and we held each other for the first time in what seemed forever and it was the nightmares that fled.

"What about your cybernetic twin?" I said finally.

"Off line." Kate shot a glance at Gwen. "We had a long talk first; I know what she did—what I did. Should we tell him?"

"We'd best. He'll figure it out eventually. Hart, did you think Edelson would bet his life and his mission on just one indicator?"

Oh, no. I thought. My stomach knotted. "The navigation system," I said. "Receive only."

"Garbage in, garbage out," Kate said. "His instruments told him he was burning prograde. If he looked at the clouds at all, it was as a check; but as you pointed out, his Earth expectations would have failed him here."

"You killed him," I said. Chaos help me, what was I going to have to do now?

"He killed me," she answered in a quiet, cold, voice.

My mind whirled. Who in the Universe would convict her? Still, cold vigilantism was against all my principles. I settled down on our couch, followed by Gwen and Kate on either side of me.

"Anyway," Gwen added, "it was Kate's cybernetic double that did it, not her."

"But Gwen," I protested, "it was her, or at least we all took it that way. Are you saying that if we become electronic simulations and do something, then go back, we're not responsible for it?"

"Different threads of consciousness," Gwen said. "I'll admit we've created a bit of a problem here, not the least of which was the setting aside of the Asimovian rules which are, in some respects, our human rules." She sighed. "It requires deeper thought."

Kate looked directly at me; she knew the score. "Are you going to arrest me?"

I shook my head. I'm still not sure I shouldn't have, but I was content at this point for the law to work out the precedents at some time in the future at the expense of someone else's family.

Gwen changed the subject. "Our replica scheme worked," she said. "Kate says the look on Edelson's face when he saw the zirconium could have told the story, but we didn't suspect him, for real, at that point. There was no 'other' data; the only way he could have known it was a fake is if he knew where the original was, and knew it was too far away for us to get it here." She looked at me through the corner of her eye. "But where is it and how did you know where it was?"

I smiled. "I knew as soon as I read Dimundi's note. If Edelson had switched it once, he'd likely done so more than once. We'll need to get confirmation, of course, but Edelson's reaction was almost as good. I'm sure the relic is hidden in the safest place imaginable."

"Getting old," Gwen said. "Slipping."

I stroked her hair. "You just don't think like a criminal. I think it's in the display case in the Vatican, right where it's supposed to be. If Edelson had gotten his access without being discovered he could have returned it from here without doing anything physical to give anyone away."

I chuckled. "Can you imagine the consternation as yet another apparent switch happened in the middle of the most intense physical security imaginable? Some might have ascribed it to diabolic intervention. Others might have taken credit for a miracle."

Gwen exhaled. "I've lost track. How many of these things are there and where are they?"

"Four, at least. Edelson's high-quality fake was switched for the real relic using Zapata's thumb. He demonstrated it was fake under scrutiny—it was, of course—and switched back the real one when they decided to cover up the loss. Now

Edelson wanted to keep the action as far away from Earth as he could get, I suspect. Out here, he'd have only a handful of people to bamboozle. So when he found out the Sánchez's were going out here, he slipped his replica into her bags.

"María took it to be real when she discovered it. So did Hector, who, I think, made the crude fake, replica number 2, that we saw—probably getting some blood from María during a physical argument. María never knew about the switch—Hector had nicked it in the right place and that's all she had to go on. When Edelson came to retrieve and declare false the replica that could tie him to the theft—it was gone and he got Sanchez's crude replica instead. That, I suspect, cost Hector Sánchez the replica, his hand, and his life because Hector could give lie to any ransom demands.

"Now, Father Dimundi already suspected Edelson from what Hector had confessed, but couldn't tell anyone else, so he took action himself. When he visited Gannon, he took our replica, number 3, then followed Edelson to the shuttle, and managed to switch the replicas before he was discovered and suffocated himself by getting into a spacesuit without a life support module. He had the one María had nicked, the original fake, the one that Edelson had first substituted for the relic, then resubstituted before coming out here."

Gwen nodded. "So that's Edelson's replica that María has now. We should confess before they get confused." She sighed. "But not until María is fully recovered."

Nice and simple. But I knew better. "The trouble," I said, "is that nobody but Edelson knows how to distinguish his replica from the original from the time of the second switch on Earth. We assume he made that switch because he appeared to know the original wasn't in the Saturn system. But there's no way I know of to back that up forensically."

The only database will not distinguish them."

"The zirconium-90?" Kate asked.

I threw up my hands: "His replica had it. I'm sure my scenario is correct, but I have no way to prove it."

Gwen laughed musically and turned to the window. "So why should the provenance of the relics of a modern saint turn out to be any clearer than those of the medieval ages? The more things change . . . Eclipse time."

The tiny, brilliant Sun set swiftly beneath Saturn's clouds as Saturn High Station's orbit brought them into eclipse. I began to see the moons and stars. Gradually the Milky Way began to fade in until my eyes grew accustomed to total dark and its ghostly luminous band stretched full across the window. I could see the galaxy edge-on, the center bulging in a Sagittarius too full of brilliant unblinking stars for any constellation to be easily recognized.

"Back on Earth," Gwen said, "every clear night, all night long, they had to deal with *that* as they fought their wars, as they died of sickness and age, and as they struggled to survive in between. It

was too much for them.

"To shield themselves from its vastness, to avoid dealing with the atoms of life and the impersonal chaos of heaven, they built a box of superstitious invention around it and themselves. *That* box, with its walls painted with angels and demons, its lid carved with slogans, its inside filled with superstition—that is a true relic—a relic of the age of chaos, of swords, of death, of fire, of martyrdom and of blind faith in those who claimed a special relationship with God. However worm-eaten and full of holes that box appears to us, there will always be those who feel more comfortable inside it."

I took Kate's hand and she leaned against me. "Do you begrudge them their comfort?" she asked Gwen.

The stars blazed down about the ghostly back-lit ring plane.

"No," Gwen said. "But I wonder how long one can look on the face of God and still not see." ■

[Editor's note: Hartigan O'Reilly and Gwen Chryse first appeared here in "A Calendar of Chaos," December 1991.]

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Thanks for the Memories

Kyle Kirkland, Ph.D.

For Jerome Corbell, it was the best of times and it was the worst of times. The best part was that he woke up and discovered he'd successfully dodged cancer, having frozen himself 200 years earlier to wait for a cure. The worst part was that he now inhabited another person's body—Corbell's "memory RNA" had been transferred from his original body—and more unpleasantness was on the way, compliments of a vicious totalitarian society.

So it goes in Larry Niven's novel *A World Out of Time*. Niven is one of my favorite authors and I thoroughly enjoy his work, particularly this book; it was originally published in the 1970s, and I think I've read it at least four times. There's just one thing that bothers me: "memory RNA" doesn't exist. RNA does not store memories.

But a surprisingly large number of science fiction authors in the '60s and '70s employed RNA as the vehicle of memory. RNA is ribonucleic acid, a large molecule whose main role in biology is in protein synthesis (for a good review of proteins, see M. Todd Washington's article "Proteins and Protein Engineering," *Analogue* March, 2000). RNA has several functions, one of which is to code for the appropriate sequence of amino acids in a protein, having first used

DNA—deoxyribonucleic acid—as a template. Like DNA, RNA has a sequence of components called nucleotides, and the information content of the molecule is derived from the sequence.

Why did many science fiction authors use RNA as memory storage? Probably because quite a few scientists formerly believed that RNA did store memories.

The question of how memories are stored has long interested psychologists and neuroscientists. Memory is based on *change*; an experience or event that will be remembered must change or modify something in the brain. But exactly what is being changed?

One possible solution: maybe there are "memory molecules" which maintain records of past experience—coding for memories in their chemical structures, which are altered by the organism's experiences. Several experiments in the '60s and '70s purportedly demonstrated the existence of such a molecular code, the molecule being identified as RNA. Although for a brief time the idea was quite popular, memory RNA was always controversial and the experiments were difficult to replicate. Today there are virtually no neuroscientists who believe in it.

So what does code for memories? Perhaps I should form the question this

way: What's the currently prevailing theory of memory coding?

These days, it's almost universally accepted that memories are stored in synapses. The electrical activity of brain cells called neurons is responsible for most, if not all, of the brain's cognitive functions, and neurons communicate with one another via synapses. A synapse is a structure which straddles the membranes of (usually) two neurons. Basically, a synapse is defined: (1) as a place where two neurons' membranes come close to one another, *and* (2) by the presence of certain highly specialized proteins which mediate the communication process. (I'll describe the process in detail a bit later.)

Synaptic physiology is presently one of the most important areas of neuroscience research. Neurons that are connected together with synapses form networks which process information, and the manner by which they do so is very much affected by the properties of the synapses. So the idea is that memories are represented by synaptic properties (such as strength of the connection); these properties are changed by the organism's experience and thus form a record of past events.

Maybe that's not as nifty an idea as RNA memory. Certainly it rules out transferring your memories by simply collecting your RNA and injecting it into some convenient receptacle (such as another body, or if you were unable to borrow or pirate someone else's, perhaps an appropriate mechanical device). But does the current synaptic theory of memory mean that transferring memories is impossible?

In a way, it does. You can't extract your memories and separate them from the brain—memories are an integral part of the brain's architecture.

But that doesn't stop you from *replacating* memories, which in principle isn't difficult: all you have to do is copy the synaptic architecture. That's different from what happened to Corbell,

whose consciousness was transferred along with his memory RNA; replication wouldn't do that. It would instead produce what I'll call a "memory clone." (Please note that I'm not referring to a clone of one's genetic material, which is a vastly different subject.) But replication can be just as interesting as transfer. Ever read the novel *Farthest Star* by Frederik Pohl and Jack Williamson?

I'm actually quite surprised that science-fiction authors don't write more about memory cloning. Many authors envision future societies dominated by artificial intelligence (AI), but they assume it'll be based on artificial algorithms. Although such algorithms may be fine for some jobs, they're not right for others. Think about corporate executives making business decisions, professors grading exams, editors evaluating manuscripts, doctors examining patients—while all of these jobs can be delegated to employees or perhaps to a sophisticated AI, many professionals wouldn't like that. They prefer to exercise their own judgement, based on their own intuition and memories, and not rely on someone else's or on an abstract algorithm. (Naturally, there could also be interesting problems with memory clones, as deftly portrayed in Pete D. Manison's novelette "Pyscraper," *Analog* November, 1999.)

How could memory cloning be done? Well, that's a bit speculative at the moment. But of course that's why it's so much fun to think about.

First, we need to discuss synapses and see what we're up against. Then we'll look at some pretty cool technology that scientists and engineers have already designed, and we'll extrapolate from there.

Synapses, The Stuff of Memory

There are two basic categories of synapse: excitatory and inhibitory. Excitatory synapses will tend to make a neuron more active, inhibitory synapses make it less active.

It's a little game that neurons play. Neurons are electrically active and they do their job by transiently elevating their electrical potential; these millisecond impulses are affectionately known to neuroscientists as spikes or action potentials. When a spike occurs in a neuron, that fact is transmitted across synapses, which generally affects the receiving neuron in either one of two ways: it makes the recipient more likely to fire a spike of its own (in which case the synapse is excitatory), or it makes it less likely (inhibitory synapse).

In this way, networks of neurons somehow process sensory information, produce movement, generate consciousness, choose appropriate behavior, make plans and predict probable outcomes, contemplate the universe, develop scientific theories, read and write science fiction. It's impossible to describe just how amazing that is to me.

But we're discussing synapses here (I have to remind myself).

Synapses are complicated. You might think that synapses would be simple if the action potential just traveled right through the synapse, as if it were a conductor linking the two neurons. Actually, for one type of synapse, that's pretty much what happens. But for most synapses, it's more complex than that.

Figure 1 shows what happens. (Figure 1 is highly simplified, so please don't try to infer too much from it.) The spike travels down the one neuron's *axon*—which is sort of like the output “cable” of a neuron—and reaches the axon terminal, where it stops. But it has a very important effect: it liberates packets, or “vesicles,” of molecules which drift randomly through extracellular space. The molecules are called neurotransmitters, and some of them just happen to encounter the membrane of the recipient neuron. Specifically, they might encounter special proteins called receptors embedded in the recipient neuron's membrane. The receptors mediate whatever is going to take place in the re-

cipient neuron; usually this involves a change in the neuron's electrical potential, and possibly some biochemical reactions. (The recipient neuron is usually called the “postsynaptic” neuron, by the way; the other neuron is “presynaptic.”)

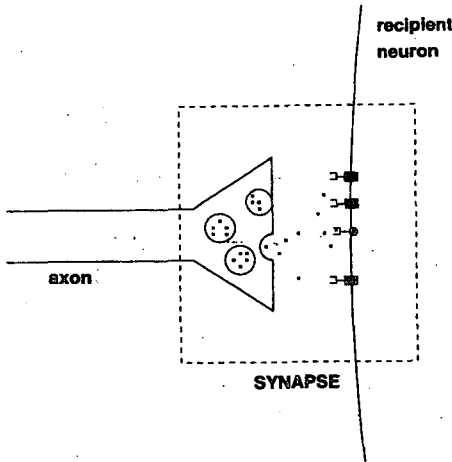
That's synaptic transmission.

Since each step in the process is yet one more place that something can go wrong, neuroscientists sometimes wonder why the brain would make communication so difficult. Supporting all the underlying synaptic machinery isn't cheap, either—it takes plenty of energy. So why is synaptic transmission so complex?

The answer, perhaps, is related to this article's topic: this is where memories live, in all of the properties and parameters and complexity of synapses. Each step in the process is not just a potential failure point, but also a point that can be regulated and tweaked, providing another knob, another control that can be adjusted to fine-tune the brain's operation and its memory storage.

The evidence that synapses are the stuff of memory is pretty strong. Many of the experiments have been conducted by Eric Kandel and his colleagues, using a rather unattractive marine mollusk known as *Aplysia*. But the findings seem to hold for other species, and important work has also been done on fruit flies, mice, rats, and others. Evolution seems to be somewhat conservative when it comes to memory mechanisms.

I should point out that the type of memory I'm referring to in this article is called “long-term memory,” to distinguish it from other classes of memory. Scientists have formulated several different classes, based on parameters such as time and category of thing to be remembered. (And scientists have argued endlessly about how memories should be “correctly” classified.) I'm not going to describe these classes here; it's not relevant to the discussion. I will tell you this, though: unlike short-term memory, long-term memory seems to require pro-

Figure 1**Simplified diagram of a synapse.**

tein synthesis—so RNA is in fact involved, although not in the way it was originally believed.

Making Memories

Let's imagine that we can make a bunch of neurons. Never mind for now what we'd use to make them, just assume that they can be made.

We want simple neurons. In real life, neurons are highly complex biological cells and a lot of biochemical stuff is going on in them all the time, but we really don't care about all of that right now. Our neurons will simply have a "state" which we'll represent as either a "1" or "0" (in other words, they're binary devices). The state will represent the output of the neuron.

These neurons will be deadily dull unless we connect them together with synapses. So, let's make them into a network; each neuron will make a synapse on all the others. For any given neuron,

its input will therefore consist of the output of all the other neurons.

Think of the 1 state as representing a spike; conversely, when neurons are in the 0 state, they're essentially turned off. The spike or 1 state will be conveyed to the other neurons via the synapses; how much influence that will have on the postsynaptic neurons' state depends on how strong we make the synapse. It will also depend on how we want the neuron to be updated—that is, how the neuron will select its state. (Call that the neuron's state function.)

Suppose we set the synaptic strengths, or "weights," to be some number. In the simplest scenario, the neuron's state function could be just a linear sum and threshold. We sum the synaptic weighted inputs and if the sum equals or exceeds the threshold, the neuron's state is 1. Otherwise it's 0.

Example: Suppose we have a network of three neurons, A, B, C. Let neuron B's synaptic weight to neuron A equal 0.25

and neuron C's synaptic weight to neuron A equal 0.5. Set neuron A's threshold to 0.75. To update neuron A's state, we compute as follows: (B state) $\times$ 0.25 + (C state) $\times$ 0.5. If B's state is 1 and C's state is 0, then we have $1 \times 0.25 + 0 \times 0.5 = 0.25$. Since 0.25 is less than the threshold of 0.75, A's state is 0. That's the output of A—it would not, in this case, spike. In fact, A won't spike unless both B and C do. We would similarly assign weights and thresholds to the other synapses and neurons.

You might be wondering how we would go about choosing all the synaptic weights and thresholds for the network. Actually, the numbers we would choose depend on what we want the network to do; more on that later.

In the example above, A has only two inputs—the outputs of the two other neurons in the network. But you could also have other inputs to neuron A (and to the rest of the neurons) from other sources, and you could treat these inputs similarly—weight them and add them to the sum. In fact, we would usually have at least one external input to each neuron. These inputs are external in the sense that they come from outside of our network. They might come from sensory organs or other “input” devices, or perhaps our network's external input is the output of another network.

As an economical notation, we could represent the state of the network by simply listing the state of each neuron. If there are eight neurons in the network, 00100001 describes the state of the network when only the 3rd and 8th neurons are spiking.

Permit me to break here for a moment, as I pause and listen for readers' questions. Believe it or not, I think I can actually hear these questions, despite the large gap in space and time between the reader and myself. This is what I'm hearing now: “Why does the author drone on so much about the states of neurons?” “I don't understand, what's the big deal about synaptic weights?”

“What does all of this have to do with memory?” “Do I need to stop by the market today and pick up some milk?”

Okay, let's cut to the chase.

The neural network stores information, in the form of synaptic weights. Think of it this way: an external input comes along, say 01010110 for a network of eight neurons. That's the stimulus. After neurons update their states, the network will have a certain state, say 10011100. That's the output (which, of course, depends on the synaptic weights and the manner in which the neurons are updated). So, the output state 10011000 is *associated* with an input of 01010110. (Provided the network always goes to this state when it gets an input of 01010110. Our little deterministic network will do so.)

And that's the memory.

It's not like a computer's memory, is it? A computer stores information at a specific address in its memory chip (or disk); it “remembers” the information by retrieving the data from the appropriate address.

Evidently that's not true for the brain. The brain doesn't remember by storing information at an address, or by storing it in the chemical sequence of certain molecules; it remembers by an appropriate change in the way neurons process information. A memory is distributed across a number of synapses and it's more of a *process* than a thing. (If it were a thing, wouldn't it require a little person inside your head to “read” it? And an even smaller person inside that person . . .)

Perhaps memory works this way. A stimulus impinges on the brain; the stimulus could be anything, but let's say it's the appearance of a friend, which makes a two-dimensional image on your retina. This stimulus causes some of the neurons in your visual system to go to a certain state, thus invoking a memory of your friend. Actually, the stimulus would probably jog several memories associated with your friend. He recently mar-

ried. He drives a blue Chevy Silverado. He owes you money.

How are memories consciously invoked by the states or activities of neurons? Good question; no one has the foggiest idea. Well, some people do have ideas, but the ideas are definitely foggy. Memory is studied by psychologists in terms of mind and behavior—the macroscopic perspective—and by neuroscientists in terms of synaptic changes (called “plasticity”)—this is the molecular, or microscopic perspective. But no one knows how to integrate the two perspectives. We know a lot about the mind and we know a lot about neurons but *how neurons create the mind* is one of the enduring mysteries of science.

And don't get the idea that the synaptic theory of memory is completely proven. It's not. But experiments do show that experience causes changes in synapses, often specifically in the way that scientific hypotheses have predicted. It seems to be a plausible model of reality.

Back to our little toy neural network. As it turns out, it can be improved considerably.

As of now, we can send it a stimulus, which will produce an output (i.e., the resultant state of the network). And that's it—or perhaps the network resets itself to all zeros shortly afterward.

But what if we configured the network to send its output back to the input lines? This is called feedback; the state of the network will affect its input, and that in turn requires updating, and so on. It's obvious that this will cause the network to cycle.

There's a very important question to ask about anything that cycles like this. Does it just keep changing constantly, cycling through an indefinite number of states? Or will it ever settle down, finally reaching a stable state in which no further changes will occur? If it reaches a stable state, we say that the network converges to that state. We'll examine

this in a moment.

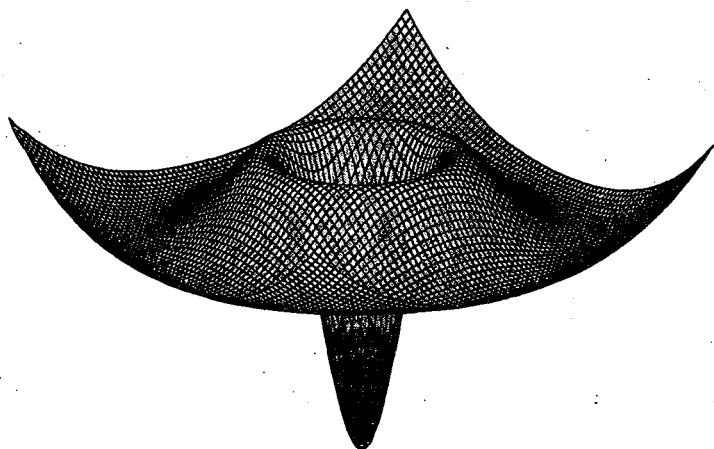
Does this have any relevance to how the brain really works? It turns out it does.

Neural networks in the brain have a lot of feedback. That's cool, but it's a bit dangerous. When the feedback is excitatory—which means that the output of active neurons tend to cause even more activity—we call it “positive” feedback, and that can create highly undesirable stability problems. (If there were no such thing as inhibitory synapses, you would have to wonder how the brain avoids exciting itself into a constant frenzy of activity. Unfortunately, that happens in some medical conditions which apparently affect inhibition: the seizure disorders, or “epilepsy.”)

Fortunately for our model network, it turns out that if you choose the parameters (and state functions) with care, then it will converge. John Hopfield proved this back in the early '80s. He also showed the existence of a certain function—computed from the synaptic weights—which is minimized as the network evolves and changes state. The function is sometimes called the “energy” function, perhaps to invoke the following analogy: think of the state of the network as a ball, rolling downhill, until it reaches a valley, which is the state that minimizes the energy function. Often the energy function is in fact portrayed as a surface (see Figure 2), although in reality it generally has many more dimensions than a surface.

So, you can generate an appropriate energy function for your needs, by judicious selection of the synaptic weights. Perhaps you want a valley here, a hill there, a little house with a picket fence over yonder . . .

There are various algorithms to compute the synaptic weights, but I don't want to discuss them here. You can also make the network more complicated by adding layers and subnetworks; furthermore, some readers may have noticed that there are interesting issues concern-

Figure 2**Example of an “energy function.”**

ing the *order* in which neurons are updated. Let's not worry about that stuff for now.

Instead of discussing the specifics, I'd rather tell you the reason why you'd want to have networks with feedback and energy functions. Consider this: the states of the network near a minimum—a valley—will fall toward the bottom as the network evolves in time. People call the state at the bottom of the valley an “attractor” because it seems to attract the states around it.

It's important to have this sort of configuration. If, for example, the memory of my mother is a highly specific state, to which other states aren't attracted—say at the top of a hill, using the energy surface analogy—then I'll only recognize her in one highly specific way.

But that's not true, since I'm able to recognize her in nearly an infinite number of ways: from various angles, at various distances, while she's wearing vari-

ous clothes, hair styles, and so on. All of those slightly different stimuli, each representing Mom, are somehow recognized. Maybe the reason they're recognized is that they all ultimately fall into my “Mom attractor.” (I wonder if that would be something like one of Plato's ideal forms?)

Using this theoretical framework, it's also easy to conceptualize the formation of associations, which are so important to memory. Networks can be configured so that, instead of single states for attractors, you can get a short cycle, or sequence, of states. (Not an infinite cycle which would fail to converge, of course.) One memory leads to the next, proceeding with logic and precision. I recognize Mom, and this, perhaps, prompts me to say, “Hi, Mom. How's the new job?” Inevitably followed by: “Can I have some money?”

The real neural networks in the brain are much more complicated than the

simple models we've talked about here, of course. Model neural networks are often called "artificial neural networks," or ANNs. ANNs have been an active field of research for the last few decades.* By the way, you'll probably hear them often referred to as "computational" devices, not memory devices, because many people concentrate on how such networks compute, not what they store.

One more thing: ANNs are generally the domain of engineers and physicists. Being trained as a neuroscientist, I'm not fluent in mathematics and engineering. At the end of this article, I've listed two books on neural networks that have been helpful for a nonengineering person like me: *The Computational Brain*, by Churchland & Sejnowski, and *An Introduction to Neural Networks* by Anderson. If you speak engineering—and everyone should learn at least a little; even I survived an engineering course on neural networks in college—then I would suggest *An Introduction to the Theory of Neural Computation* by Hertz et al.

Which synapses store memories?

If synapses store memories, where in the brain are the most important synapses? Or are memories distributed over the entire brain?

I suspect that memories can be found almost everywhere—that's because most areas of the brain are likely to have synapses which are to some extent modified by experience.

But different types of memory are probably located in different areas. Many of the memories that are cognitive in nature—perception, knowledge, personal history, stuff like that—are probably found, for the most part, in the cerebral cortex. There are many reasons for believing this, coming from various experiments and observations over the past century and a half.

I also want to mention one other part of the brain, called the hippocampus, since it's often associated with memory and you might have read something about it. (The word "hippocampus" is derived from Greek and means seahorse, and the brain structure was so named because its shape apparently reminded anatomists of that animal. I think it just goes to prove that even staid anatomists can have vivid imaginations.) Actually, there are two hippocampuses (hippocampi?), one for each hemisphere of the brain. (Almost all structures in the brain are bilateral.)

Many research studies have implicated the hippocampus in memory—but the hippocampus evidently does not store long-term memories, its role seems to be helping them to get formed. For instance, bilateral damage to the hippocampus and related structures causes an interesting behavioral deficit: long-term memories that were previously stored are not affected but new memories are seldom established. People suffering from such damage can remember what happened to them before their injury, but most experiences after that point are continually erased because they fail to get stored in long-term memory.

Unfortunately, no one yet knows how the hippocampus works.

Memory Machines

So we can create an artificial neural network that can store memories, in a manner (theoretically) similar to how the brain does it. When do we start downloading our memories and creating replicas of them in silicon?

Well, what do we need to do? We only have to find the synaptic strength of all of our synapses and then build the correct ANN.

There are about 10^{12} neurons in the brain, although let's say we're only inter-

*See Rick Cook's article "Neural Nets" in *Analog*, August, 1989.

ested in the ones in the cerebral cortex. Estimate that as ten billion neurons, i.e. 10^{10} . Each neuron makes about 10^4 synapses on average. So, we're looking at 10^{14} numbers.

Quite a bit, isn't it? It's actually even more than that. In a genuine biological neural network—like the ones between your ears, not the neural networks on an engineer's drawing board—synaptic strength is determined by a large number of factors, each with its own time course and each probably contributing to memory in a unique way. Things like the biological state of receptors, and the state of ion channels (which are proteins involved in the production of electrical currents in neurons), and the proteins that govern neurotransmitter release, and heaven only knows what else, all of which may play a role in your memory. It's an astronomical amount of data.

Want to download your memories to a computer? Better get a *big* disk.

But who says you have to get all of them? Maybe you're only interested in a subset.

Better yet, maybe we can settle for a crude approximation. If we can't create a perfect replica, how about something that's close? Sure, it would be slightly deficient but it would still be you, more or less—well, hopefully less.

How crude an approximation you're willing to put up with depends on what you want the thing for in the first place. But whatever the application, we have to be able to get the data we need. So how do we get a "read-out" of the brain? Unfortunately, that currently presents a problem.

We require measurements of synapses and their properties, particularly their strength. There are various tools to do this, and it's not too difficult for a pair of neurons. One way is to record simultaneously the action potentials of a pair of neurons, and then compute what's called a cross-correlation function, which simply tells you whether the ac-

tivities of the neurons are independent or not—and if not, lets you estimate the strength of the relationship (or, in other words, the synaptic connection). It works fine unless you happen to have a lot of neurons to record from, in which case it becomes a real chore.

I was excited when I saw a recent paper by Büchel and Friston that examined the connectivity of *regions* of the brain, instead of single neurons, using neuroimaging methods and various statistical tools. Resolution is much poorer, of course, but we're after an approximation, aren't we?

What we really need is a three-dimensional map showing the activity of neurons with as good a resolution as we can possibly get. Then we present a series of stimuli and record the activity, from which we can get some idea of connectivity. (For instance, if the activities of two areas are strongly correlated—i.e., when one is highly active the other is too—then the areas are probably connected with excitatory synapses; the strength of the connection can be estimated from the strength of the correlation.)

However, neuroimaging does have fundamental limits as to how good its resolution can be, as do microscopes, so it will never show us everything we'd like to see. Another problem: neural connectivity is affected by mechanisms such as attention, so that introduces a further complication. But as noted in a recent article in *Science* [volume 286, page 2261], imaging is continuing to improve and is even being employed on non-humans (formerly it had been pretty much limited to humans). As a consequence, I believe that new imaging techniques will be tested and developed; indeed, the article mentions a new and intriguing method of tracing neural connections, which is just what we need.

Realistically, however, it will be quite a while before we can make memory clones using data gathered only from the

brain. That's okay, because we have another source of data: behavior (which is the output of the brain, so to speak).

Engineers working on AI sometimes rely on behavioral observations, particularly when they're working on the type of AI known as "expert systems." Engineers try to construct expert systems by gathering knowledge from human experts and formulating it into various algorithms. One difficulty, of course, is that humans, even experts, don't always know themselves how they do something and are unable to generalize their knowledge. And simply watching their behavior does not necessarily give you any clue as to what the experts are thinking about when they make their decisions.

That, of course, is why neural data is so important. But observing behavior is also important, particularly when it can be tested in laboratory conditions. (Which is done frequently in the field of human psychophysics.) Especially if a set of stimuli could be found such that, by watching how a person (and the brain) react to this set of stimuli, you could predict their behavior in all or most other situations.

Can such a set of stimuli be found? Can it even exist? I don't know for sure, but there is a precedent; engineers do something like it all the time. It's called Fourier analysis.

Suppose you have a system—which is just anything that transforms an input and produces an output—and you want to predict how that system will transform any given input. You could test it on all possible inputs, but that's time-consuming (or impossible). It would be easier if you could find a set of inputs that could, by various combinations and permutations, represent all possible inputs. You then test the system on this set, and from this data you could predict the system's behavior to any input. And that's what happens in one particular application of Fourier analysis: the set of inputs is sine waves of various frequen-

cies and phases. It works because any reasonably behaved function can be made by an appropriate summation of a set of sine waves. (Some functions require integration.)

But there's a catch. The system needs to be linear, which means the sum of all its responses to the sine waves individually has to be the same as its response to the sum. However, the technique works on systems that are only approximately linear—which is a good thing, since *almost all* systems that are called linear are actually only approximately linear.

What I'm suggesting here is that perhaps some such set of inputs—i.e., stimuli—exists for some types of memory and cognition. If so, it would make the testing of behavior and the acquisition of neural data much less burdensome.

There are, of course, some problems with this idea. The brain isn't necessarily linear, and sometimes its departures from linearity are drastic. That could be restrictive, or even kill off this idea entirely. Another problem: I don't know at this point what sort of stimuli might work.

But it's worth thinking about. Any reduction in the amount of data required to create a memory clone would be extremely useful. And I strongly suspect that the data can be minimized; as far as systems go, the brain has notoriously many redundancies. ■

About the author: Kyle Kirkland recently completed his Ph.D. in neuroscience at the University of Pennsylvania, where he is now a postdoctoral scientist. He reads everything he can about science—a steady diet of research papers, nontechnical articles, and hard science fiction.

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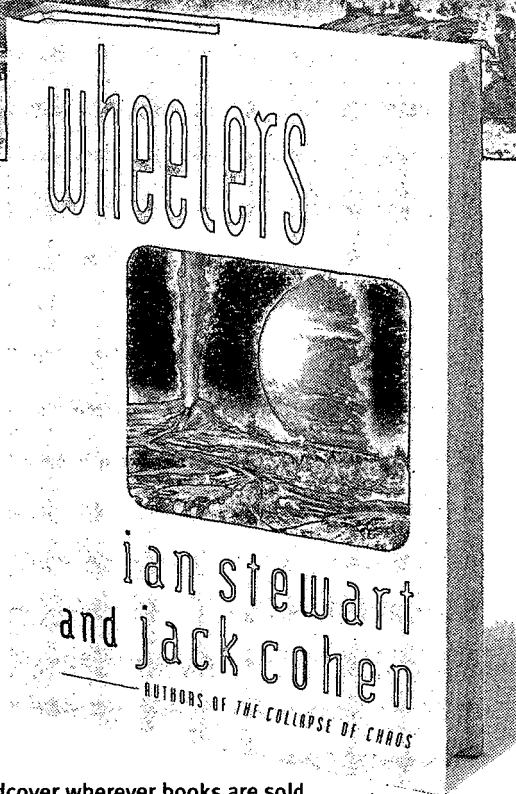
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Settlement

Edward M. Lerner

Have you ever had a sense of *presque vu*, the feeling that a familiar place or situation isn't quite what it seems? The dream started like that.

My company integrates websites. We buy web servers, database management systems, e-commerce packages, and add customer-specific content. I'm not getting rich, but it's a living.

I was in my office—but it wasn't *my* office. My metal desk had been replaced by an expanse of mahogany; my plain carpet by a hand-knotted Persian over pegged oak planking; my souvenir trade-show posters by framed oils. The room dwarfed my real office. Across the table, a frowning *presque vu* customer leafed through paperwork, scribbling on a legal pad.

"Is there a problem, Mr. Gray?"

"How did the total get so high? It was only an upgrade to my DBMS."

Leather creaked as I leaned back in my chair. "Only? It's a complicated process, I assure you." Before he could formulate a response, I added, "I'm sure we discussed this."

Gray squirmed in his (cloth-covered) seat. "You mentioned the upgrade itself and an installation fee. Now these other charges appear."

"I'm sure we discussed it," I repeated soothingly. "These are all customary items."

He fidgeted with the handle of his briefcase. The ID tag held a business card for "Gray & Associates." He opened his mouth, then thought better of it.

We reviewed page after verbose page, mostly boilerplate. He questioned the need for most of it, and the associated charges; I responded glibly, in the most unctuous and condescending of voices. It was poor sport: my dream self had parried such queries many times before.

"Yes, an upgrade *is* \$200, per line 1022 of the Software Installation Reconciliation Form. Naturally, we also have the documentation fee of \$150 and notary fees of \$50." Of course, I couldn't *do* the work without completing the necessary papers, there was no benefit to notarizing them, and my receptionist was a notary. "You'll want a copy of the papers, hence the xerography charge." At a dollar a page.

More closely resembling his name with each passing second, Gray rallied to ask, "And these 'Items Payable In Connection With Transaction?'"

"Those are charges from SoftSell, the distributor providing the upgrade."

"But the database is already listed."

"SoftSell incurs expenses retrieving a package from inventory and ordering its replacement. They must confirm that you've licensed the Version 2 application before authorizing an upgrade to 2.1. Naturally they bill for preparing their papers, itemizing their charges, and so forth. You'll notice," I volunteered helpfully, tapping a \$30 item with my platinum pen, "the fee for couriering their papers to my office."

From his eponymous hue, Gray turned an equally unhealthy red. "A courier? What about mailing the papers? For \$30, I'd have dropped them off."

I smiled. "You're not bonded, Mr. Gray." Neither was my son, who'd delivered the package.

"Why two courier fees?"

"SoftSell receives a copy of the executed paperwork. It'll be couriered back." Bobby frequented the next-door music store; his share would buy a CD.

Steam appeared to issue from my customer's ears. "And this tax-service fee?"

In my dream, otic vapors seemed a normal occurrence.

"SoftSell owes \$10 for sales tax on the transaction. The \$40 covers preparation of their tax filing."

The nightmare wouldn't end. My squirming customer heard, without enlightenment, about a pest-inspection fee (I ran a virus checker), a site survey fee (I ran a directory command—yes, an operating system *was* installed), and a credit report.

Total charges for the \$195 upgrade and my \$200 installation fee came to \$1106.95. Wearily, Gray took a checkbook from his briefcase.

"Ahem," interrupted my dream self, "For amounts over a thousand dollars, I *must* insist upon a cashier's check."

His pen stopped. "You ran a credit check on me—and billed me for it. Why do you need a cashier's check?"

"Company policy," I shrugged, although I'm the company for all intents and purposes. "Would stopping by to-

morrow be an inconvenience?" I added a day's interest to the total as he stared.

I woke up screaming into the night at the rapacious monster that I'd somehow become.

I'm proud of what I do, and strive to do it better every time. My *doppelganger* had taken a straightforward task, a process that I perform regularly, that I've streamlined and optimized, and somehow created an individualized abomination. My evil twin practically itemized each staple. I considered the petty venality of triple-spacing paperwork to maximize buck-a-page Xeroxing, and wanted to vomit.

SoftSell was a reputable vendor; they'd never take part in such a paper-shuffling conspiracy, pyramiding billable charges through the ludicrous exchange of standard forms. We *never* courier anything. It's 2001, for God's sake—we use the Internet.

Why would anyone tolerate this? A sneering echo of my dream self answered: had Gray not paid every extorted penny, I'd have slapped a lien on his business. Contesting my charges would have meant retaining the services of another systems integrator, whose services would come no less dearly than my own. My inner demon smirked: even then, what artificer questioned his fellow's fees?

So Gray told himself that software upgrades aren't done often—better to just pay, and put the unpleasantness behind him. Seething, he wrote the check.

That was always the way.

I got up this morning with a bad taste in my mouth. The moo-shu pork at the back of the fridge might have been too old, but I don't think that was it.

I think it was refinancing my mortgage yesterday, in the posh law offices of Gray & Associates.

As luck would have it, I'm supposed to upgrade their website soon. I'm looking forward to it. ■

Vibes

Laurence M. Janifer

*The line between basic needs and fatal dangers
can be quite subtle.*

There is always something, and it is almost always Something Else.

For Fits—which isn't even the real name of the planet—it's going to have to be a total rewrite of the textbooks on planetary formation. There isn't supposed to be a way a planet can develop with fairly large supplies of most of the noble gases, and an almost total lack of, just for instance, iron. That, according to our very best experts (and I am not really about to knock an expert just here, by way of being an expert myself), is very firmly against the rules.

The planet, actually, doesn't seem to mind—and we may in fact have our new theory any decade now: the residents of Ravenal, which seems to average about one and a half hard-science new-style Nobel Prizes per inhabitant, have been ordering headache-killers by the old-fashioned tun. The inhabitants of Fits don't seem to mind much either way; their attitude is the perfectly sensible one that used to go: "J'y suis, j'y reste," which I once heard translated, by someone else who had my sort of scrappy Classical education, as: "I am Swiss, and I am going to lie down now." I'll explain what being Swiss is, when it isn't being a cheese, some other time.

I did say that Fits wasn't the planet's name, and it isn't. It's a romantic sort of story, I guess: the discoverer was a fellow steering a private exploration ship (there are such things, though not from the Comity worlds, where the Government refuses to test its efficiency against

any other form of life). In accordance with old and heartfelt traditions on his world—Bolyai, one of the Frontier Worlds, with a heritage that goes back to Welsh and Hungarian, I think (I'll explain what those are when I get around to explaining Swiss)—he named it after his own particular light o' love.

Her name, unfortunately, was Phthasithphia. This is not quite unpronounceable, though you do want to take it slow around the curves the first few times you get it on the road; but after about ten minutes of careful thought humanity in general agreed to call the place Fits. (Nobody seems to have suggested anything new to call the light o', which is probably just as well. And no, I don't know whether the gallant explorer ever married his Phthasithphia, and I certainly don't know what they called their children, if any. *Junior* might work.)

The native inhabitants, in fact, don't run to much in the way of fancy names for the world; they get along with Place or Here. They are intelligent, and they are living beings, but they are also a little stranger than most aliens seem to be, from our viewpoint—even before the recent events you haven't heard about yet. I'll get to them; give me time.

The main thing is, they are definitely not Life As We Know It.

They consist (as far as can be measured) of a small number of millions of atoms apiece, which puts them on the visible side only if you have a good light microscope. They are, more or less, matter as opposed to pure energy, but

the argument is still going on, really, because they're primarily vibratory: the vibrations of the particles in those atoms reflect and echo and add and subtract and do all sorts of complicated things, and the net result for each such aggregation is an intelligent being. He has no special *shape*, you understand—but he's casual about that.

A creature that small hasn't enough room for anything sizable in the way of a brain, let alone a mind—and the current theory is twofold: either a) the brain and/or mind is composed of some other sort of material in some other sort of dimension, and is linked to the (measurable) creature by some arcane means we haven't yet got a handle on, or b) even a very small and insignificant brain can give rise to an appreciable sort of mind, by some arcane m. we haven't yet got a h. on. Take your pick; that argument is also ongoing. (Part of the argument revolves around the notion that the minds of human beings also exist in this other dimension, and hook into our rather larger, nicely measurable brains in the same arcane way. Go ahead: show me why this isn't so.)

Two notes need to be added immediately. First, there's a little uncertainty attached to any such vibratory pattern, and so the definition of a given inhabitant, in vibratory terms, doesn't go all the way down to every individual damned atom, let alone each quark or what-have-you; according to a learned friend of mine, the definition—the individuality of any given inhabitant—rests on a sort of average-per-thousand, or possibly average-per-four-hundred, atoms, and, offhand, that does sound close enough for whatever practical purposes might arise.

Second, there is a constant, fairly high background level of radioactivity involved. This, of course, helps to make the vibratory picture even more complicated than you might expect; Fits has a much higher background than most habitable planets, and the natives seem

to prefer life on those parts of the planet where radiation levels are highest—something like the way human beings prefer to live near water.

The radioactivity on Fits couldn't be considered entirely normal, either, even for radioactivity. We—large-size beings of a certain wistful charm—have learned very slowly to tailor almost any element into almost any radioactive isotope of the same element, with virtually any sort of half-life, from nanoseconds to decades—a trick, by the way, that in the late twentieth century might have got any one of us burned at the Stake, or electrocuted at the Chair, as a witch, or witchess, depending on sex.

On Fits, the same sort of trick, involving the noble gases, of all things, seems to be played naturally—by Nature, of course. Whether that makes Mother Nature a witchess is something we can discuss in another seminar, possibly in another life.

And how intelligence, let alone a sizable controlling brain, really does hook into all of this bazaar of vibratory excess nobody is at all sure; there are any number of people who will sit you down and prove to you that it can't. They will not sit *me* down for any such purpose, not for longer than ten seconds, because I refuse to argue religion except with someone who knows he has one. The two theories noted above may provide clues, and there may be a third theory somewhere, too—or a fiftieth. I'm fond of the extradimensional theory myself, though I have known a few creatures, in my travels, who appear to have developed into passable imitations of humans, while boasting even smaller brains than the inhabitants of Fits can be measured out as owning.

Definitely not, in any case, Life As We Know It. But that superstition is slowly dying at last, several centuries after it should have.

Life As We Know It isn't going to occur anywhere except where We already are, more or less by definition; if it's

somewhere else we don't yet Know It. What rules are changeable in the course of the game, what rules have been greatly misunderstood by human players, and what rules absolutely have to be followed no matter what do not in any way add up to a body of knowledge we have any handle on whatever, and without that handle it's fairly silly to talk about Life As We Know It unless you're talking about human beings—and who Knows them anyhow?

I got to Fits the way I got to this sentence, in a circuitous sort of way; I'd gone to Kingsley to look up a few old friends and make a lot of new ones, and somebody on Kingsley was engaged in a long-distance argument with some Fem-Lib type or other on another planet, and Fits had come up in the conversation. I'd never even heard of the place, and I'd heard of it even less when my friend spelled out its real name for me, very, very carefully—but when she started to describe the inhabitants I got interested, and about ten days later I was on my way. Fits isn't especially near anything, but it isn't in the Magellanic Clouds either; it takes about three days from Kingsley by space-four, if I may boast a little.

I may have the only civilian Unlimited Space-four Card in existence, given to me by a grateful (if you beat its teeny little head in) Comity some time ago. It enables me to go virtually anywhere, virtually any time, and satisfy my curiosity.

Curiosity being, quite literally, what I live on. I'm an information collector. A Survivor has to be; you never know, in my trade, what bit of information you are going to need in a tearing hurry, and at the second you find out that you need it, you are not going to have the time to look for it.

I was curious from the start about Fits and its Life As We Sure As Hell Don't. And while sometimes curiosity doesn't pay, there are times when it fails entirely to kill any cats; as in this case, quite the reverse.

Fits is habitable by human beings only if your standards are very, very low and your tech is very, very high.

The atmosphere isn't breathable, and the average temperature is depressingly low, no matter where you light. And, speaking of light, while there is some, there isn't enough to read a letter by, and most of what there is doesn't appear to come from the local sun, which is a bit too far away for any sort of cheery household illumination. (That romantic explorer named the sun for himself, with even less success than he'd had in naming the planet; his name, though I have no idea how he got it on Bolyai, was Watson, and what that leads to is the echo of an old Abbott-and-Costello routine (my Classical schooling cropping up again; sorry): "What's the name of that sun?" "Watson." "That sun." And so on.)

The planet has a compressed hot core, though not iron. And though the core is not transparent, most of the rest of the planet is, in a vague sort of way, so everybody is lit from underneath. This makes even your best friend look much too much like a Thing from Beyond for your comfort, or for his. Or, even more sadly, for hers.

The solution was, of course, the Dome, and I landed on a field connected by burrow to the Dome.

It's big enough for a small city to camp under it, but there are only a few house-type structures and other necessary buildings, and the area is for the most part inhabited by a Diplomatic Corps—just in case the human race absolutely needs to get the locals on its side for something, some day—and by a small military post, in case the diplomats aren't persuasive. It is not at all clear to me how you use military force on a gang of vibratory beings of microscopic size without simply erasing the entire Fits autothone population, but God alone knows what a military post, generally speaking, is going to have on its mind; at times it might even have a good idea or

two, as has happened. Maybe the military types could even figure out how to get to the extradimensional minds and/or brains of these teeny folk—if, of course, that theory turns out to describe actual facts.

I climbed out, shed my suit and connections, greeted people all around in the friendliest possible way consistent with a great hurry to get indoors, and settled, for the duration, at the planet's only hotel—which ranks about as low as any hotel I can remember offhand.

Yes, I know I *was* indoors all the time, the Dome being a Dome. But it is built to feel as outdoorsy as possible, by people who Know Life, they tell me, at least Human Life; on an inhospitable and deadly little planet of strange properties and stranger looks, I do not want to feel outdoorsy, and I find it hard to imagine anyone who *would* want to—but while there are indeed experts, as I was saying a while back, there are also damned fools.

I put up with the hotel very politely. I was, after all, curious, and when my curiosity gets fed the odds are that I will get fed too. And I had the strong feeling, based on the snippets of data I already had, that somewhere on Fits was a situation with which I was going to want to help out.

This, in fact, turned out to be so. Wilfrid Dazer, a nice old fellow with a full head of hair the color of very old butter, and a voice that needed oiling, mentioned it to me on my third day. I'd been spending my time poking around in the Fits Dome Library (a disorderly pile of actual, physical disks meant for actual, physical loading into small, improbably boxy-looking computers) and not finding much of interest beyond some basic information on the locals, and a series of short pieces on the Evils of Not Voting, written and distributed, God knows why, a solid century ago; as a connoisseur of Evils I filed that one away, and in fact vowed then and there never to vote

again, but it did not give me the thrill an Evil is supposed to provide.

Dazer asked me why I'd come out to visit Fits, and what official connections I had. I told him I had no official connections, which nobody ever believes of anybody, and that I'd been curious about the autochthones—it's a fine word for a planet like Phthasithphia—who were about as good an example of Life As We Had No Damned Idea It Could Be as I'd ever heard tell of.

He said: "You're not trying to boost this Charris notion, are you?"

I said: "What Charris notion?" and he said:

"Ah." We were sitting in the reading room of the Library, which was full of slightly dusty screens and overstuffed chairs, like a gone-to-seed ancient Club. "You haven't even heard of it?"

I told him I'd never even heard of the locals (no sense overdoing a really good word) until a few weeks before; I didn't even know what, if anything, they called themselves.

"As far as human beings are concerned, they call themselves Vibes," Dazer said. "Some military type suggested it, I have no idea why. From 'vibrations,' of course."

"Fine by me," I said. "There's always a spot for good vibes." The allusion went right on by Dazer, of course, without stopping to say hello, and he went right on himself:

"Charris is the name of an interfering young woman who appears to be attempting to kill off the Vibes altogether. You're sure you don't know about all this? It was fairly big news when it happened, just a couple of standard years ago."

Every planet thinks it heads off the news nets five nights in seven; it's a commonplace, and why fight it? "I may have been off-world around then."

"You know that the Vibes are constructed of individual atoms whose vibratory frequencies—somehow encased in what might be defined as a loose

field, if there is such a thing, and in this case there has to be, whatever theory says—create the individual being. The atoms are always those of noble gases, and each Vibe, so to speak, is composed of exactly one noble gas.”

“There are neon Vibes, xenon Vibes, argon Vibes and so on,” I said, and he said:

“Exactly so. And they are not, repeat not, immortal.”

“I never said they were,” I replied. “Nothing much is.”

“People get the silliest ideas,” Dazer said. “These beings are very small, and each is composed of a single noble gas. They interact minimally with their surroundings, and there does seem to be a human tendency to assume that, if you don’t interact with your environment in some massive physical way, you don’t age or sicken or die. Ghosts, for instance, walk through walls and float in mid-air, demonstrating their lack of interaction with the physical world, and establishing their immortality thereby.”

“Rasmussen’s biting saurians walk through walls, too,” I said. “Of course, they do leave a good deal of damage behind them.”

Dazer gave me the sort of thin smile that goes with the fixed belief that one has a sense of humor, and no sense of humor. I shrugged, and he said: “Exactly so,” again, and went on to explain Charris to me.

Charris, it seems, had become preoccupied with a disease that had seriously attacked the native population. She wasn’t at all an unfriendly or evil type; she really felt for the teeny Vibes, and the disease, whatever its cause, had been wreaking some havoc with them.

It was a process that used to be called marasmus, just before vocabularies got more high-tech than processes, and I really don’t have a handle on what it is called now, except it would certainly not be anything as simple as Fits or as charming as Phthasithphia. It’s a wasting away, and microscopic vibratory forms

of life can do that just as well as us big beings.

The cause, the Vibes thought, was a small change in the local atmosphere that introduced slightly different vibratory backgrounds into their world. We, the exploring giants, were not to blame, and probably the change had little or nothing to do with us; the Dome was a good insulator, so to speak. The Vibes were very clear about all that, and when Charris wanted to help them to deal with the plague of marasmus, the Vibes listened carefully and patiently, and then started screaming for help. There is nothing like a person who means well, without having any real grasp of meaning.

And that was where Wilfrid Dazer had come in, about a standard year before. Dazer had a nice relationship with a few of the Vibes—they could both appreciate light-and-shadow effects as art of some kind, apparently, though Dazer saw them as optical effects and the Vibes seemed to see them as fringe-ruled vibratory fields, whatever that might come to in sensual experience.

And the Vibes, though scared by their epidemic of marasmus, were flatly terrified by Charris. They wanted her stopped—at once, if not sooner, and (they said, perhaps rashly) by any means Dazer or anyone else could come up with.

It seems Charris felt that All Life Was One—the fact being, of course, that sometimes it is and sometimes it isn’t. She was sure she knew the cause of the epidemic. Radioactivity was not good for living things.

Once again, the fact is just that sometimes it is, and s. it i., depending on what living thing you’re talking about and, for that matter, what “good for” means: I can get rather fond, in a remote sort of way, of a tagged radioactive that will diagnose my illness, if I happen to have one, where nothing else stands much of a chance.

All this is elementary, of course, but

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people do seem to forget the elementary in their search for the obvious. And Charris had done just that; the trouble was that she had influence.

She was a member of the military team, attached to liaison with the Diplomatic Corps, and she was getting off missives to Comity forces of all sorts—not as a prelude to invasion, but as a form of pressure. A military force always has great influence with a Government, for the same reason that your arms and teeth have great influence with your liver and lights. Charris was using that influence to Do Something about the radioactivity.

And if she succeeded, the Vibes would die—and if that happened, she would blame the epidemic; the cure of No Radiation just hadn't been implemented in time.

If it surprises you that people can be as silly as Charris was being, you haven't been out in public very much, have you?

As I say, she wasn't an evil or uncaring person. She wasn't a really ugly and grating one, either, I found out; I listened to Dazer's description of what she was trying to do—which was longer and more detailed than the one I've just given you, but you have the gist of it—and went off to see if I could scrape up any sort of acquaintance with her. Maybe she would listen to reason, as long as that wasn't what I called it.

We met at my hotel, in a restaurant that was trying very hard to produce edible food. I settled for something called Ragout of Tofu, as I hope you never have to, and a wine imported from, of all places, Mars Dome, where nobody has ever succeeded in growing recognizable wine grapes; I had the distinct impression the stuff had been pressed out of golf balls. She had something I never managed to recognize at all, and I don't want to think about it ever again, if you don't mind.

Charris—whose full name was Rolsia Charris, by the way, and who wanted me to call her Rolsia, which I tried to re-

member to do—was very earnest. Radioactivity had to be the cause of the marasmus. It had meant such terrible things to human life, we had an obligation to see that it didn't harm other intelligent life now that we could control it for our own purposes (if we could, that is; she really wasn't allowing any slack at all).

Radioactivity, I insisted, wasn't all bad. What was more, the Vibes had lived in a constant atmosphere of radioactivity—nothing like the core of a fusion plant, say, but a very much higher background than human beings could stand—for all of their history, as far as we could figure out; why would it suddenly start to harm them now, after centuries and probably millennia of calm?

"Because, Mr. Knave, a line has been passed. The accumulated level has simply become too high for them to withstand any longer. We've got to help them; we don't want to see an intelligent race deeply harmed, decimated, perhaps even extinguished."

I took one more forkful of the Ragout, and sighed very deeply. "No, we don't," I said. "But they're not human beings. They're different. They have different needs."

"A need for radioactivity, Mr. Knave?" she said. "That hardly sounds plausible."

Oh, God. "The universe is very varied," I said. "It's possible."

"And you would risk the fate of an intelligent race on a vague, unlikely possibility?"

Oh, God and All His Relatives. "As regards the Vibes," I said, "it isn't vague at all. It's what they live in. Think of them as animate, intelligent Geiger counters."

Rolsia Charris looked at me with as cold an eye as I have ever seen on anything above the emotional level of a codfish. "Mr. Knave," she said, "I did not think that you would debase such an argument with cheap jokes."

God, All His Relatives, and All Their Pets. "I'm not joking," I said. "They live in a radioactive environment. For that

matter, so do human beings; it's a question of degree. The Vibes need more radioactivity than we do, that's all; turning it off, by whatever damn means, will kill them."

"Mr. Knave," said the codfish, "I am forced to wonder what your interest is in this matter—and who is paying you to attempt to prevent amelioration of the Vibes' life pattern."

And Their Heirs And Assigns. From that sentence, there was no place for the conversation to go, so it didn't.

I had the strong feeling that Dazer and his own group of hangers-on, given a little additional influence, might defeat Charris, with whatever group she had managed to persuade or entice or simply befuddle along. I got ready to swing a decisive weight, and believe me, I was thinking of it; but then I had a chance to talk a bit more with Dazer, and things came altogether unstrung.

Dazer, it seems, had his own ideas about what the Vibes needed.

But before I talked to Dazer, it occurred to me, I really should talk to a Vibe or so.

This proved so much more difficult than I'd thought it was going to be that I actually felt some real respect for Dazer, Charris and everyone else on Fits. No, a great deal of real respect. They had managed to talk to the Vibes, and they had managed to make sense.

Getting the Vibes to understand you turned out to be the easy part. You understanding the Vibes was something else again; creatures who have no distinct shape, or at least *small* creatures who have no distinct shape, apparently tend to be a little careless about the shapes of other things—like words, sounds and the like.

The Diplomatic Corpsman on duty; a young fellow named Roe Jerrue—tall, reed-thin, with black hair like a busted paintbrush and a long, solemn face—explained it to me in a single casual phrase. "There is very wide allowable

variation in sound," he said. I had no idea what this might mean until he pushed a sort of silent (to human beings) buzzer or vibration-maker of *some* damn sort and, on the other side of a translucent wall, a Vibe appeared, suitably enlarged by the beam focus. There is no use in telling you what he, she or it looked like (Vibes, I understand, have got sex; so do bean plants) because nothing I might say about its first ten seconds would be true of its second, third or fiftieth ten seconds.

What the Vibe said was: "How is the ice today, Master Kundu."

"You, too," said Jerrue without a quiver. I was making notes headed *Ritual References Among Vibes* to myself when it dawned on me that what I had heard wasn't *exactly*: "How is the ice today, Master Kundu," but was more along the lines of: "Who is the pace todody, matter Cuckoo."

Wide allowable variation. Indeed. Jerrue told me that one developed an ear for Vibe conversation after a while, but it felt to me as if it would have to be an ear shaped like a Klein bottle. I never did get to talk directly to a Vibe; I worked through a translator, with occasional pauses when Jerrue's startlingly good ears gave him something that didn't sound in the least plausible (at one point the Vibe appeared to be insisting that radar declivity was vital to his aspirations).

The Vibe was fairly insistent about being allowed to solve the problem of the marasmus epidemic on his own, or rather with a convocation of Vibes, instead of dragging human beings into it; we were not, it seemed, equipped to understand.

Having spoken with Rolsia, I had some notion of where he had gotten that idea. But others of us, I insisted, were quite sane—and I did guarantee him that anything we were going to do that might have any effect on Vibe life and civilization would be opened for his inspection and approval first.

This was finally agreed to, and I went off cheerfully to my conversation with Dazer.

That conversation, unfortunately, was nowhere near as satisfactory.

"They need to live by themselves," he said earnestly, in the same old Library. "It's contact with human beings that's giving them all this trouble."

I raised an eyebrow. "How so?"

"I haven't the faintest idea," he said earnestly, "but it's simply too much of a coincidence. Here we are, we come into contact with the Vibes, and—within a comparatively few years—they come down with an epidemic. Could that be coincidence?"

Well, I once had lunch with a fellow who stuck me with the bill, went out into the bright sunlight of good old Earth, and was run over by a cleaners' truck. Could that be a coincidence? Surely if he'd paid for the lunch—or if he'd had lunch, even at the same restaurant, with somebody else entirely . . .

I tried explaining that to Dazer, but it didn't really go over well. Dazer had seen a rabbit, and he'd seen a dog chasing it, and he was firm in his belief that the rabbit had caused the dog.

And that conversation put things squarely up to me. Either I came up with some sort of answer to the local epidemic, or else a) the Vibes were doomed, courtesy Rolsia Charris, or b) the Vibes were isolated, with none of the fun of banging up against another intelligent race, courtesy Wilfrid Dazer.

Neither of these answers looked as if I could allow them to happen and walk cheerfully away. On the other hand, was I a Vibes expert?

Well, no. But I rather thought I knew somebody who could pass for one, back on Ravenal.

Charles Hutson Bellemand MacDougal had paid me very well, a few years back, to smuggle atomics on Apelles (and it made me go cold to think of the expression on Charris' face if she ever

found out I'd done anything as sheerly poisonous as all that). Charles Hutson Bellemand MacDougal (it's one of those names; you always want to shake it full out, like a flag) had used my expertise, and paid me very nicely for it. I thought of paying him—he doesn't actually *need* the money, but few of us do, we just enjoy the Hell out of having it—and wondered how he'd take that, and decided I was better off asking a favor.

So I told Dazer to hold off on making any sort of decision regarding anything whatever having to do with the Vibes, their Heirs And Assigns, and anything else more complex than what he, Wilfrid Dazer, personally, was going to have for breakfast. I had a real tame Vibes expert, I promised him, coming in from Ravenal.

The name of the planet had its usual effect; anybody on Ravenal gets to be thought of by almost any outsider as an expert in one or more of the real hard subjects, the ones that do not repay bluffing. Dazer, impressed with my casual tossing-off of the name (I'd practiced a little in my hotel room; "Ravenal" is no easier to toss off casually than "heat-death of the Universe" until you fine things down a bit), promised almost eagerly.

Then I told him to find a line to Rolsia Charris and her little group of Thinkers and Dreamers, and to give her the same caution, leaving my name out of it; for Rolsia, "Ravenal" would have to do all by itself, and despite a lingering doubt I rather thought it would. My name, attached to the same bit of news, might have her flying into a foaming rage and, for all I know, declaring my ship illegal because it had atomics in the structure.

The big trouble, of course, was that I really didn't have very much of an idea of what I wanted Charles Hutson Bellemand MacDougal to say. He was no more a Vibes expert than I was, and all I knew was that the two people who'd talked to me about Vibes, and who were

supposed to know something, if not in fact very much, were both wrong.

As there are always lots more ways of going wrong than of going right (it isn't the Universe that's built this way, it's the nature of thought), this did not seem to be really helpful.

But Vibes were dying.

Well . . . I have run into the death of an entire intelligent race, and I've mentioned it in a report somewhere and I don't want to go back and mention it again. But in this Universe, Things Happen. Nobody has to like them, encourage them, abet them, or serve as their Heirs and Assigns; they just Happen. If you are extraordinarily lucky, you may Unhappen one or two of such Things, and I was hoping to be extraordinarily lucky.

If not . . . not, damn it.

And I would have one more thing to forget, and not enough time to do the job properly. Holding a wake for an intelligent race is something that ought to take up several hundred lifetimes, and I just don't have that sort of room in my schedule just now. (Unless, of course, the Reincarnationists are right—in which case I still don't, because I won't know it.)

So I sent off a space-four message to Mac, and I began mulling things over while I waited for a reply. I'd already guaranteed an expert, and I had my fingers, toes and eyes crossed that Mac was healthy and available; of his good will I had no doubt, but things do come up now and again—as I was saying a while back, there is always something.

The reply arrived within fifteen hours, which is a long time to spend worrying in a hotel that serves Ragout of Tofu. (Its breakfasts were nowhere near as imaginative, I had discovered, consisting mainly, in my case, of a sort of coffee made out of a local soybean derivative, and a sort of egg made out of real eggs, but very long ago.) Mac would arrive in two and a half days, give or take an hour.

Mac doesn't have my sort of civilian

Unlimited Space-four Card—nor will he ever need one. He has degrees the way some people have pocket lint, and he is a full professor in Molar and Molecular Physics at Ravenal Scholarte, and if he tells someone he needs to check something out in another galaxy the someone will build him a ship, pack him a lunch and feel grateful if Mac thanks him. (Which Mac, being a polite fellow, would undoubtedly do—if just a bit absent-mindedly.)

Mac, it developed, had been distantly interested in the Vibes for some time (though "distant" is the word); from where he stood, anything that made its life out of atomic and subatomic vibration posed sixty or seventy interesting puzzles (leaving entirely aside, as we did throughout this small adventure, the theories about their brains and minds), none of them, probably, stateable in terms you or I—especially I—could understand. He scarcely needed to fake an interest in order to grab off a space-four round trip, in other words—though he does enjoy playing that sort of game, as who does not, and he managed to fill someone's head with a great deal of wind about the Inner Consciousness of the Down Quark. I hope, whoever it was, that he's had some fun with the idea.

And just maybe . . .

Naw.

By the time Mac arrived, I had most of my thoughts assorted. Mac, of course, was curious as to just what they had been, and when he heard them he unasorted them all over again, and kindly—with just the trace of a smile here and there over the next few hours—put them together again much better, thank you. With full attention paid to such things as scattering wave potential, reinforcement quantum levels, and Haussman's Equation of Isolate Resistance.

I've been assuming, it occurs to me now, that all those things are real. For all I actually know, they are my personal

version, courtesy Charles Hutson Bellemant MacDougal, of the Inner Consciousness of the Down Quark. How could I ever know?

The reference books, tapes and other such materials might tell me. But would I put it past Mac to have been playing games with the people who arrange such stuff? I mean, he's one of the people the compilers of reference data come to for the data.

Well, at worst, no harm done . . . I guess.

And Mac didn't like my only real idea at all. I'd thought of pushing through a Rule that the entire world of Fits (with the exception of the Dome) be tested once a year and commanded to contain such-and-such a nice high level of radioactivity—the way to swing a bureaucracy over to your side is to give it something bureaucratic to do—but, while that would effectively stymie Dazer and Rolsia Charris, it wouldn't do much for the marasmus.

I knew that, but I didn't think of myself as a Vibes healer. Mac, on the other hand, went straight for the core of the matter.

"Wasting away," he said. "What would that mean for a race like this?"

"A few less atoms every day," I said, having learned that much anyhow. I'd warned him, very briefly, about the amenities on Fits, and he'd brought a few basic supplies—coffee, sandwich materials and so on. They weren't top-grade, because Mac doesn't occupy himself much with the higher amenities, but they went down, in my hotel room, as if they'd been supplied by Lucullus himself. "Maybe they just shrink away until the sheer number isn't enough to support life—if there's actually some sort of relation between numbers of atoms and life."

"Which there may be," he said. "The fact is, Knave, nobody knows anything about this subject. Which is why everybody has a theory." He drank some coffee, and I drank some coffee and lit up

another Inoson Smoking Pleasure Tube (you can think of them as guaranteed-safe cigarettes, if you're still hung up on the Puritan Reaction; or you can do the sensible thing and not waste thinking time on them). "But what we want here is a way to cure, or reverse, this wasting-away process. And how does one cure a sequence consisting of 'a few less atoms every day'? I should think the number would be in the tens of hundreds, by the way—perhaps one order of magnitude larger."

Clearly, what one did, I said, was to supply new atoms to take the places of the ones that fell away. And when Mac asked me how, I said: "By the wheelbarrowload, or the truckload. I have *no* damned idea."

"It's an interesting puzzle," he said. "Clearly, atoms must be supplied to a Vibe in a general sort of way; I think we have to assume that the particular vibratory scheme—and the equations of its state must be fascinating to fiddle with—is a constant for any given Vibe. Or as near a constant as molar physics allows when we're down to small numbers. And the supply is getting thin; that's what we have to correct." He stared at the bare hotel-room wall, and muttered six or seven arcane phrases to himself, and I sat there trying to look helpful. I did say: "Why is the supply getting thin? Isn't that the big question?" but Mac ignored me and went on talking to himself. This always strikes me as good technique, even when I do it; I've always thought of it as telling the back of my head what's wanted, since it is much smarter than the front of my head.

"Somehow or other," he said very carefully, "we have to be able to supply specific atoms of a specific element to a specific Vibe—and that wouldn't be so bad, because microscopic servings of the element might do the job if the Vibes have some way of assimilating such bits as needed—and we might assume for the moment that they do; they certainly have *some* way of selecting out

what we might call their nutritional necessities."

I said, intelligently: "So?"

"So something must continue to supply particular atoms, with particular vibratory properties—as well as the atoms being of the particular gas native, so to speak, to a given Vibe. Even protons don't last forever."

"And they can walk right through walls," I said. Mac stared at me, and I waved a hand grandly. "Ignore it. The strain is getting to me."

Mac took in some more coffee, and stared at the wall for a few more seconds. "What sort of process supplies particular atoms with particular states more or less on demand?" he said. "If we could know that, we could see *why* the supply has been getting thin. And we might be able to rig a new source of supply."

"Offhand," I said, "it doesn't sound like an answerable question. Unless you're just going after some sort of Cosmic Logistics Department. In which case we could put in our order—"

"—have it stamped *approved* by the Logistics Bureaucratic Bureau—" Mac said.

"—get a reply telling us supply would be made in six weeks—"

"—and wait six months while supply was actually made—"

"—of the wrong isotopes," I said, and Mac said:

"Aha. In fact, eureka."

Now, *eureka* is what Archimedes is supposed to have been yelling as he ran naked and wet through the streets of his home town, having just discovered the law of fluid displacement. This has always seemed to me a very plausible story, because the event would be hard to forget; it kept getting told because people kept remembering it. The word means: "I have found it," and if I saw a naked wet man running through the streets shouting: "I have found it!" I might not think of the law of fluid displacement, but I would not forget about

the scene in any great hurry.

However, what Mac had found I had no idea, except that he seemed to believe that I was the finder. I said: "What are we celebrating?" and Mac said:

"Very long lives to Vibes."

I stubbed out my Pleasure Tube, and said: "And a happy Bastille Day to you, too. Are we going to be able to accomplish this, all of a sudden?"

Mac, beaming all over his dark chocolate face, nodded. "You gave me the key," he said, and when I asked what key that might have been he said: "Isotopes."

He managed to explain it fairly simply, and then I asked him to explain it again and he broke it down further, and after a third go-round I began to get a glimmering.

It was really (Mac said) very simple.

"I was trying to do the job backward," he said "I don't have to care where the supply of atoms comes from. All I have to know is that there is one."

"But it's getting interrupted," I said. "That's where the marasmus comes in, isn't it?"

"Not exactly," Mac said. "You see, it's a radiation problem."

And when he said that, Rolsia's face condensed itself right out of the hotel-room air and snickered at me. "You mean that Charris woman was right? They're sickening and dying of radiation poisoning? I refuse to believe it, God damn it."

"Well," Mac said, "in a way. In a way."

"The next thing you're going to say," I told him, "is that the Vibes have to be isolated."

Mac nodded. "In a way," he said.

Dazer and Charris were dancing around the room like insubstantial, and therefore immortal, ghosts. I would have been grinding my teeth if I could have found a decent portable grinder.

"Don't worry about it," Mac said. "They were right, and you were wrong—and being wrong is much more

helpful." I don't suppose I looked persuaded; God knows I didn't feel persuaded. "It is all too possible," Mac said, "to be all too right—and end up by exterminating the problem instead of solving it. And one thing we are both determined not to be is an exterminator. The Vibes are fascinating people; they ought to survive and prosper." That big grin came back. It has always made me feel as if I'd suddenly had about a drink and a half. "And they will," he said, and I beamed back for no reason except that it felt right.

Not all too right. Just right enough.

And, one standard month later, I was on my merry way—full of tofu and old eggs, but there are worse things, so I am told. Dazer and Charris were mutually happy, the Vibes were well on the way to a full recovery and then some, and Mac was staying on, despite a complete lack of real coffee and edible sandwiches, to "see the Vibes through—they're really a fascinating people, you know," he told me. I'm not sure whether they fascinated him as people, as elegant and impossible demonstrations in molar physics, or as something else entirely—or if, in fact, it was the Vibes that truly fascinated him. But I'll get to that.

The Vibes had in fact needed isolation. There had also been a radiation problem. The trouble was that both facts had to be applied together—and each fact had to be understood. There is a lot of Fact around, these days, to a very little of Understood.

I can't explain it with Mac's elegance—which is lucky for both of us, because a) you wouldn't understand me, and b) I wouldn't have the faintest idea what I was saying. But, as I clawed it slowly back into language with which I am fairly comfortable, the song of the Vibes goes a little like this:

A marasmus was taking place. The number of atoms in a given Vibe was decreasing. But (Mac asked himself) how

could this be? The surroundings hadn't changed—given the insistence that the Dome didn't affect Vibes, and there was no good reason it should; not to mention the fact that the Dome had been there for a while without noticeable effect, the Vibes had sent up no alarms, and in fact the marasmus was a very recent phenomenon. (Mac suspects that it is a recurrent phenomenon, but that the time-between-epidemics can be very long.)

Well, atoms aren't immortal. But some atoms change faster than others. These are generally known as radioactive.

The Vibes don't mind radioactivity; in fact, they need it. But if a Vibe is made in part of stable atoms of, let's say, xenon, and also radioactive isotopes of xenon—and this not only sounded likely when Mac supposed it, it proved out over a week of careful, even finicky, discussion and measurement involving the Vibes (who did their own measurements of their own neighbors; it's very handy, in fact, if you absolutely have to get precise figures on microscopic beings, to have some microscopic beings around to collect the figures for you)—the radioactive atoms are going to disappear first. Some will disappear rapidly, and under just the wrong conditions enough will start to disappear so that the shrinking of a Vibe becomes noticeable, then meaningful, and then, unfortunately, fatal. (The wrong conditions haven't quite been pinned down yet, but they do not involve either humans or the Dome. They seem to involve a solar neutrino cycle of some complexity.)

A heavily radioactive environment will tend to foster this process if the process hits a high enough level; thank you, Rolsia Charris. The answer, however, is not to remove the Vibe from the environment.

Not quite—or not permanently.

The answer is, in part, to borrow an idea from Wilfrid Dazer, and isolate the Vibe—while he is undergoing what amounts to replacement surgery. Like

giving a man an artificial hip, in fact.

Under what amounts to a blanket of as near vacuum as was both necessary and possible, the Vibe can be surrounded with radioactive isotopes which will become part of his or her body—the process of getting these atoms from the surround into the Vibe is something Vibes do, obviously enough, and maybe even something that Vibes understand.

These isotopes, if chosen (or created) by means of current witchessery) very carefully, will slowly “decay” into natural parts of the Vibe. That was Mac’s inspiration: a Vibe can wear a prosthesis for a while. The prosthesis ought to be isolated from the rest of the vibratory structure, if only so his friends, pets, heirs and assigns can recognize good old Duncan Vibe, or whoever—but while human beings don’t generally need fields that small, such fields are not (Mac tells me) difficult to make or project, and I’ll take his word for it.

Once the new material is attached to the Vibe, so to speak, the vacuum blanket is removed and our friend goes limping through his world for a while, as he gets used to his artificial hip, or whatever that might be for a Vibe whose sense of shape is not well developed.

Slowly, though, the artificial hip turns into the real thing—and there you are: a healed Vibe, non-marasmic and a New Person altogether, healthy as the day he was born—or whatever day it is Vibes have to start things off with.

Dazer felt vindicated: isolation was a part of the solution. I don’t know if he’s ever noticed that it was only a part, and I certainly didn’t have the gall to tell him; what good would it have done?

The Vibes are happy. The epidemic has been controlled, a cure is available, and (on a variety of theoretical grounds,

he says) Mac assures them that the epidemic will blow over shortly, and not be seen again for a very long while.

Are the Vibes immortal, by the way? Given the prosthesis solution (and that’s a phrase fully worthy of a planet called Phthasithphia) one might at first think so: a new artificial part can be added at any time, grow into a natural part, and so right on forever.

But it just ain’t so; quantum effects, Mac tells me, will continue the aging process and even the general disease process among Vibes. (I hadn’t been entirely aware that there *were* any quantum effects any more, since the last rationalization of physics, but Mac tells me there still are. This seems to make him happy, and I suppose it should; it gives him a continuing field to be at least temporarily confused by.)

I am happy; it’s something, after all, to have put in my two cents’ worth toward saving an intelligent race, and I now know a great deal I never knew before, which is a coin I’m cheerful about being paid in—when actual cash money isn’t in the picture. As I say, few of us really *need* actual cash money just now—though I wouldn’t admit that except among friends.

And Rolsia Charris feels vindicated, too: radiation had been at the root of the Vibes’ problem, sure enough. I simply wasn’t willing to work for a couple of days to explain to her why she was right, let alone why she was wrong; when the Vibes seemed settled I departed for fresh fields and pastures new, as the man says.

The explanations, for Rolsia Charris, were being provided anyhow—by Charles Hutson Bellemant MacDougal.

I did say that she wasn’t an evil or an ugly type, didn’t I? ■

Who is more foolish, the child afraid of the dark or the man afraid of the light?

— Maurice Freehill

BOOMERanG and the Sound of the Big Bang

Two years ago, astrophysicists studying Type Ia supernovas discovered that our Universe is a much stranger place than we had imagined, with invisible vacuum energy accelerating its expansion. (See my column about this in the May 1999 *Analog*.) However, new astrophysical observations from the BOOMERanG experiment (Balloon Observations Of Millimetric Extragalactic Radiation and Geomagnetics), a balloon-borne cryogenic microwave telescope measurement that flew at an altitude of about 24 miles over the Antarctic, indicate that our Universe is also rather ordinary, in that its space is maximally flat. The term "flat" as used here means that the space of our Universe is neither positively curved like a ball nor negatively curved like a potato chip. It appears that in our Universe, the tendencies of space toward positive curvature from gravitational attraction and towards negative curvature from expansion kinetic energy are precisely in balance, leaving space on the average completely free of curvature.

In general relativity, the curvature of space is characterized by the density parameter Ω_{total} , which is less than 1 for negative curvature, greater than 1 for positive curvature, and exactly one for flat uncurved space. The BOOMERanG measurement has shown that $\Omega_{\text{total}} = 1.00 \pm 0.12$. There are theoretical reasons for taking this as an indication that Ω_{total} is precisely 1.

Our present "standard model" view of Big Bang cosmology tells us that about 14 billion years ago, the Big Bang started from a tiny point that explosively unfolded to make what became our Universe. In the first few picoseconds of the Big Bang,

for reasons that are not understood, the Universe expanded very rapidly in a process described as "exponential inflation." During this inflationary period, the diameter of the Universe increased much faster than the speed of light. Then the expansion slowed, and the Universe passed through phases in which the four forces (strong, weak, electromagnetic, and gravitational) separated, changed strengths, and resolved themselves, in which quarks and leptons formed and acquired mass, in which composite particles including protons and neutrons formed from the quarks, and in which the protons and neutrons combined to form primordial nuclei of deuterium, helium 3 and 4, and lithium 6 and 7.

Finally, about 300,000 years after the initial Big Bang, the Universe had cooled enough to allow the positively charged protons and heavier nuclei to combine with the negatively charged electrons to form neutral atoms. At this point the "primordial soup" of the Universe became electrically neutral. Photons of light in the medium, which up to that time had been trapped by rapid and repeated absorption and scattering with the surrounding charged particles, abruptly found themselves in a transparent medium. They became free particles, able to travel large distances without interactions.

For the most part, these photons have been traveling through the Universe since that time without scattering. However, the expansion of the Universe has stretched their wavelengths by a factor of a thousand. They reach us now, 14 billion years later, as very low energy photons of the cosmic microwave background. Their wavelength distribution, originally pro-

duced by the very hot plasma of the early Universe, is now characteristic of a cold "object" with a temperature that is only 2.73° above absolute zero.

This cosmic background radiation (CBR) from the Big Bang was first detected in the 1960s. It has been repeatedly measured with increasing precision for the last four decades, culminating with the COBE satellite measurements in the early 1990s. However, in the past five years it has been realized that the CBR has encoded within it some definitive information about the characteristics and composition of our Universe. We are only now, through BOOMERanG and similar measurements, gaining the capability of decoding that information.

Theoretical studies have shown that as the early Universe expanded, sound waves propagated through the dense medium that closed back on itself, so that the hypersphere of the Universe rang like a bell. The detailed frequency spectrum of the sound waves that permeated the primordial Universe, literally the sounds of the Big Bang, depends on details such as the expansion rate, the energy balance, and the matter density of the Universe at the early age of 300,000 years.

But how could one possibly listen to sound waves that had dwindled away and died 14 billion years ago? Fortunately, there is a way. The primordial sound waves were present at the time that light decoupled from matter to form the CBR. The sound waves, because they produced regions of compression and rarefaction in the medium, modulated the CMB, with some regions being slightly hotter or colder than others. This modulation is predicted to still be present in the CBR at a scale of less than 2 degrees in angle. Basically, to see the effects of the primordial sound waves one must look for variations in the temperature of the CBR of about 1 part in ten thousand through a peephole that spans a cone in the sky with an opening angle of 2 degrees or less, and scan this peephole across the sky.

Unfortunately, this modulation effect had not been predicted when the COBE measurement was designed, and so that measurement had an angular resolution of about 7 degrees in angle, a resolution that averaged away all of the crucial information. Therefore, it was realized about five years ago (see my column on the 17th Texas Symposium in the August 1995 *Analog*) that a whole new set of CMB measurements was needed, and that these would place very tight constraints on the parameters of the Universe.

BOOMERanG is one of these new measurements. It is an international scientific collaboration of astrophysics groups based in Rome, London, Pasadena, Berkeley, Florence, Geneva, Santa Barbara, Lisbon, Paris, Amherst, and Toronto. Because of a combination of careful design and good luck, the BOOMERanG measurements have significantly improved our knowledge of the parameters of the Universe.

BOOMERanG consists of a microwave telescope that focuses and concentrates the microwave radiation from a sky-angle of 0.2 degrees on three cryogenic Si_3N_4 web detectors that are sensitive to frequencies of 90 GHz, 150 GHz, and 240 GHz, respectively. The webs change temperature in response to the energy delivered by the focused microwaves. The entire device is mounted between shields that block the radiation from the Earth and the Sun. The sensitive aperture of the telescope is scanned over the sky, providing a 3-frequency image of the sky mapped into about 45,000 pixels in each frequency channel.

The telescope was lifted from McMurdo Station in Antarctica to the outer fringes of the atmosphere at an altitude of 120,000 ft by a large $2.8 \times 10^7 \text{ ft}^3$ helium-filled balloon. The instrument remained there, gathering data over a patch of sky with an angular area of 1800 square degrees, for a period of 10.8 days between December 29, 1998 and January 9, 1999. The balloon followed a circular path centered at the South Pole, and returned to

within 80 miles of its launch site. There the telescope was cut down and retrieved.

The raw data produced by BOOMERanG is a time sequence of signals in each frequency channel consisting of 5.4×10^7 16-bit samples per channel. This sequence had to be converted by data analysis, first into a sky map of temperature variations at the parts in 10,000 level, and then by Fourier analysis into a distribution of the spatial frequencies or angular sizes of the observed variations. It is these distributions that can be compared with models of the early Universe. If the Universe is "flat," in the sense defined above, then the angular size is expected to have a peak at about 1.8 degrees. This corresponds to a "standing" sound wave in the early Universe that has a number of maxima and minima (or "multipolarity") L in its pattern of compression and rarefaction that is $L=197 \pm 6$ or about 200.

From calculations of the standing sound waves in the early Universe, it is found that the value of L is directly related to the flatness or curvature of the Universe. For example, $L=125$ would correspond to an open Universe with negative "potato-chip" curvature and with $\Omega_{\text{total}} = 0.66$. On the other hand, $L=300$ would correspond to a closed Universe with positive spherical curvature and with $\Omega_{\text{total}} = 1.55$. The observed value of $L=200$ is precisely what is expected for a flat Universe with $\Omega_{\text{total}} = 1.0$. Therefore, BOOMERanG has accomplished a remarkable feat. It has "heard" the sound of a perfectly flat Big Bang from a distance of 14 billion light years!

But there is also another important aspect to the BOOMERanG measurements. The data on the accelerating expansion of the Universe from studies of Type Ia supernovas mentioned above places certain constraints on the parameters describing the Universe, the age T_0 of the Universe, the total density parameter Ω_{total} , the matter density Ω_M , and the vacuum energy density Ω_Λ . The BOOMERanG measure-

ments place other constraints on the same quantities. And, plotted on an appropriate diagram, these constraints form an "X," with the cross point indicating the parameter values that are consistent with both measurements.

These lead to the conclusions that the Universe has an age $T_0 = 14$ billion years, $\Omega_{\text{total}} = 1$, $\Omega_M = 0.3$ and $\Omega_\Lambda = 0.7$. The surprisingly large value of Ω_Λ , which implies the dominance of vacuum energy over normal mass-energy and dark matter mass-energy in the Universe at present, is a result that rocked the astrophysics community two years ago. This is now supported by the BOOMERanG results, which come at placing constraints on the parameters from a completely different direction.

We now understand that the space of our Universe is flat, that it is expanding at an ever-increasing rate, and that it will never recollapse to a "Big Crunch." What we don't understand is why. But physicists, astronomers, and astrophysicists around the world are working on that question too. ■

AV Columns On-line: Electronic reprints of over 100 "The Alternate View" columns by John G. Cramer, previously published in *Analog*, are available on-line at: <http://www.npl.washington.edu/av>. Preprints of papers referenced below can be obtained at: <http://xxx.lanl.gov>.

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See also the BOOMERanG Press Page on the web at: http://www.physics.ucsb.edu/~boomerang/press_images/index.html

RESURRECTION

James Van Pelt

Some barriers are very hard to transcend—which is not quite the same as “insurmountable.”

There is no beauty in a starship. Nothing obvious, anyway. A cold efficacy in the numbers, certainly. An aesthetic satisfaction in the way the hull rounds our lives, the curved corridors, the rhythm in waking, working, then sleeping again, the long cryonic near-death. But no beauty. Out the ports, frosted emptiness. Twelve hundred years of interstellar erosion scars the view. Not a star visible. Not even perfect blackness. All we have is the half-million-ton ship filled with frozen genetic material, farming equipment, and us, the Custodians, slumbering through the implacable distance, fleeing despair, pursuing a slim chance, or none. My own artistic attempts fail. No comeliness motivates the creative temperament in the metal, sturdy shapes.

Not that there aren't problems to solve. It isn't just engineering taking us to new worlds. Trust the hardware, they said, and the software too, but not the peopleware. Although we are awake for only two weeks every hundred years, when we reach Zeta Reticuli after 4,000 years, we will have lived over a year and a half. We were picked partially for good genes, long lives and patience, for our willingness to wait, but it would be unreasonable to expect there wouldn't be disagreement, grudges, relationships. So there are protocols for law enforcement, for therapy, even for onboard marriages. Everyone has certification beyond their specialty. We have doctors, counselors,

a pastor, and me, a keeper of the peace. You can't go to the stars without people. What would be the point? But I don't like it.

What the engineers didn't plan on were William and MaryJo.

Their romance must have festered long before I noticed. After six months aboard the *Resurrection*, lived in two-week snatches, MaryJo developed cryogenic phobia. Some do. It should be no different from sleeping and waking, but you know you're lying in a chamber filled with cooled gasses, and your body is corpse-still. No test can detect life's thread, while the finest balancing act biotechnology provides keeps you teetering above the abyss. It hurts, too. Before you lose consciousness, the cold pierces, and when you wake . . . well . . . it's like razored ice everywhere. For a second, you feel it. Then it's gone. Tolerable discomfort. It's efficient. A small price to pay for interstellar distance.

Occasionally, Custodians can't take it. They refuse to enter the pods. Nobody can make them. It's sad. Peopleware. As far as the other sleepers are concerned, it's suicide. For the phobic, they lead a full life—as full as wandering around the *Resurrection* can be—alone, greeting crew members as they wake for their custodial duties, pursuing whatever studies or hobbies intrigue them, until they meet us again, if they live, a hundred years later. Our bios are good, and we're long-lived anyway—we're a long way from the traditional three score and

ten—but a hundred and twenty-five years is pretty much the limit. No one makes it through two cycles.

William, a tall, olive-skinned physical-fitness buff, rushed by me. He was stripped to the waist—clothing is optional on board—a scowl in his eyes. I'm the peace-keeper, so I dropped the ion engine reports and followed him down the corridor. The living area's small. Fifty crew members work on top of each other, so disagreement is inevitable. It's a long trip any way you look at it, even when you skip fifty-two hundred weeks for every two you are awake. As far as we were concerned, we'd spent six months in confinement, and there were twelve to go. Psychological testing can give us the most compatible crew in the world, but human nature is human nature. Someone is going to blow sometime.

I passed other Custodians, some sitting at their stations, checking repair records, fine-tuning the *Resurrection*. Hardly any human artifact lasts 4,000 years. The ship would be built and rebuilt dozens of times before we arrived to colonize the new star system. The hull had to be recoated; the automated routines checked and reestablished; the few moving parts replaced; the computers themselves, eventually, needed a complete overhaul. For us the trip so far had been six months, but the ship had been moving forward for over 1,200 years. One old ship, a quarter-million fertilized ova, and four fifty-member crews, one of whom woke every twenty-five years. Quadruple redundancy. Four sets of workstations. Four sets of living quarters. If we had to, we could all be awake at the same time. Colonial equipment filled the holds, while the amazing computers did most of the work, striving toward a distant star.

William lost me at a split in the corridor. I don't think he knew I was following, but he strode forward so angry that people moved out of his way, and they all stopped me. "What's going on with

William?" "Do you think you should say something?"

"I don't know. Let me get to him, and I'll tell you." I went a few steps up one path before realizing it would take me to cryogenics. Unlikely he'd be going there. Nothing but chilled crew members and our long-sleep pods. The other passage led to the gym and dining room. If he was searching for someone—and he looked like a man on a mission—that's where he'd go. That's where she'd be, waiting for him, ready to give him the news.

I'd known three cycles ago she was refusing cryonics, just as I knew about their relationship a month out (our time). The fitness profiles go by my station. They exercised in the gym together. I'd passed them holding hands, his dark complexion a pleasant contrast to her china-pale skin. I'd come upon them in a junction in a corridor, William half-bent at the waist, MaryJo on her toes, their lips just touching. I should have seen the emotional explosion ahead.

When I got to the cafeteria, he'd found her. They sat across from each other at a narrow table, their foreheads together, staring at their clasped fists between them. I leaned against a wall, arms crossed, watching. He could do anything, anything at all, but I knew what he wouldn't do—he wouldn't join her. He was a fanatic. Zeta Reticuli or bust for him. It was in his profile. He would choose to see the trip to the end, to be a part of the settlement. He had the lowest predicted bailout numbers in the crew. William would row the *Resurrection* there if he had to.

So I watched them, cool metal against my back. I smelled vegetable soup. Coffee. An outside crew sat at the room's other end, getting ready to go out. Eating big. They'd spend a ten-hour shift checking hull plate, supervising maintenance bots, spreading nanonite paint that burrowed into the ship's skin, remaking it. They ignored the couple.

I keyed my wristcom, arranged to

cover their work. William cried. Tears glistened on his cheeks. MaryJo whispered, dropped her head so her hair covered her face. What was she telling him? There was nothing to say. She'd refused the pod. William would go to sleep, and when he awoke, she'd be ancient or dead. I stepped closer.

"It's not my fault," she said. Where's the fault? The ship would move on without her, but she would move on without William.

"You have to go," he said. His hands shook, holding hers. His elbows bore down on the table; his knuckles turned white, gripping her, and she grimaced but didn't pull away. The crew at the other end left. Maybe they knew what was going on too. MaryJo was saying goodbye to us. She was dead in a way already. Tomorrow we slept in the pods. The day after that, the MaryJo we knew would be gone. Maybe she'd write us novels as a phobic several cycles ago did. Fifty-four books before he died while we dreamed slow dreams. I read a couple. Not bad, considering. Maybe she'd paint—we had supplies for it—I dabbled in my rec time, a landscape or two. Of course, she might wander alone through the ship for a year, then climb into a pod to join us, a year older, a little wiser. No phobic had done that so far. No hope for their future motivated them strongly enough to sleep again.

I saw reason for hope, but William didn't. He looked into her eyes as if searching for the answer. What he saw offered no compromise. She was staying.

"I can't," she said, but William already knew. His shoulders collapsed. All emotion drained from him, the anger, the passion. It leaked away. He kissed her hands between his own. I knew I could go back to my station. There was no need for me here, and I had more figures to check. The engines had to stay steady in their work, processing air, keeping us warm, throwing us outward faster and faster. Our distance to go was

indescribable—it would take 4,000 years—but it could take 40,000 if we didn't slowly accelerate every day until the turnaround point. The engines had to work. The people didn't. We'd get there if the people didn't mess it up.

At my station I finalized the ion thruster numbers. They were good—the engines were good. Techs had gone over them inch by inch. Another twenty-five years of steady thrust until the next crew woke up to check them again. I knew the numbers were fine, just as they'd been fine a week ago, but I had a job to do. What saves us is efficiency. Work keeps our minds off the pods, off the hundreds of years we'd already traveled and the thousands we had left. I studied my cubicle. On the walls I'd stuck postcards from Earth: Monterey Bay's south beach; a dogwood tree in the spring, a waterfall tumbling behind it; a sunset in the Tyrolean Alps. By my desk light they generated no magic. I stared at the Alps for a long time, willing them to come alive for a second, but they didn't. No beauty, as I said, in a starship. Even lovely pictures offer no transcendent moments. I didn't go to bed that night. For the next hundred years, I'd sleep, and that seemed enough.

I didn't see the final good-byes. MaryJo didn't come to the closing. The technicians helped me into position. When we were secure, they'd help each other into their pods. The last one would climb in by himself. It was doable—going to sleep without help—but it was easier with aid. There were sensors to attach, adjustments to be made. William climbed in five pods down from mine, a fragile neutrality in his face. He didn't talk as they hooked him up. Was he waiting for her to come? How did they spend their last night together? During my melancholy the night before, I hadn't checked. I told myself it didn't matter to me. The crisis had passed in the cafeteria. Besides, numbers had to be refined and verified. My

counterpart on the next crew twenty-five years from now had to have clear figures to work from.

I shut my eyes when the lid came down. I'm not cryophobic, but it's hard in those last minutes. The imagination does its wondrous job. A hundred years! Disaster could happen. The ship could fail. Equipment could seize up. A thousand tiny things could kill me in my sleep. And what was the difference between this and death? I remembered what I always remembered just before I went to sleep: when I woke up the last time it was to a lingering memory that I'd been dreaming for the whole hundred years, and the dream had been a nightmare.

I followed William again after we awoke. He shook the sensors off his arms. Slapped them to the ground. This would be the other rough time. A minute ago he'd shut his eyes and MaryJo was a young woman, his love. They'd held hands and he'd kissed her. The skin had been smooth, as his was now, and their hearts had beat in heady rhythm. A minute ago for him, but most her life would have passed if she hadn't bested the phobia, if she still lived.

He wouldn't lose me this time. I hustled after. He was blind to my presence. To the cafeteria. It was empty. To the gym. No sign. To her workstation. Nothing. He grew more frantic. Pushed by me without seeing. Past the gardens. Through the infirmary, through the labs, through the rec room. There wasn't much ship to search. I followed into the living quarters. At her apartment, he paused. She could be dead within. Maybe dead for years. I touched his arm, and he jumped. He genuinely didn't know I had been there. He took a shaky breath, then opened her door.

I entered behind him, and we stood silent for a moment.

"Why don't you check the records?"

He sat on the edge of her empty bed, reached across the bare desk, and

turned on her station. I was glad to see it come to life—there's always the suspicion it won't.

"She's not dead," he said. The screen flashed results. "She's in my room."

Seconds later, he held her. MaryJo had grown small in the years, and her hair had thinned, losing all color. Her eyes were rheumy, her knuckles huge and arthritic, but she rose from the bed when the door opened. She met him in the middle. William murmured in her ear, and she squeezed him back. Her arms shook as they held him. No wonder; she was one-hundred and twenty-four years old.

"I should have stayed with you," he said.

Her voice had vigor, even if her body had thinned away. "I couldn't go to the pod then. When I changed my mind, I was old, and you were. . . ." She traced a finger along his firm, unwrinkled cheek.

And they both were crying.

Finally, she said, "I missed you."

William gathered her like a child, sat on his bed. "I missed you too."

And I thought about the hundred years of dreams I couldn't remember. What had William dreamed in his time? Could he bring the images up? Was there regret even in sleep?

I left them. Walked the long corridor to my station. I'd forgotten to store the postcards, and the other crews had left them up. The color had faded. All that remained of the Alps was a yellowed shape provoking no memory. I leaned with one hand against a bulkhead, staring at it. No reason to be upset, really—the cards had lasted 1,300 years. I sat, called up the figures. Did my job. Efficiency is the key word. Being busy keeps one sane. Progress reports distracted me and repair programs and the notes from the other engineers. At first I worked my work, and I tried not to think about William and MaryJo.

The reports crossed my station anyway. William abandoned his station. He spent every waking hour with MaryJo.

I'd glance at the monitors and see them sitting in the cafeteria, heads bent in conversation, his fingers resting on her wrist. Sometimes it was as if there was no age difference. She'd speak to him, then pause, waiting for his reaction, just as she had a hundred years earlier. If it weren't for their differences, I'd say they were young lovers. They remade themselves in the first week. In the second week the tenor of their talks changed. He became more vehement. I didn't eavesdrop. I could have. My job allows me. But they were no danger to the ship or anyone else. He must be saying goodbye again, I guessed. She wouldn't live to see the next crew awake. Her days were running out. William must have seen this time as a second life for them. She had changed on the outside, but her spirit remained.

The monitors showed all. I didn't want to see, but I had to. I tried to stay away. Painted instead. My station displayed the Alps, Monterey Bay, dogwood trees with waterfalls running to mist behind them. But my paintings remained flat. The ship offered no relief. Not one beautiful image. They should have known, on Earth that is, I would not be happy in the ship. Eighteen months without a mountain to climb or a stream to fish in. Maybe that's why they chose me: they knew I would always return to the pod. The idea of growing old in this falling barrel, this sterile cage, sickened me. If I could keep taking the long sleep, I would again walk on land, a sky above me and not a ceiling. Zeta Reticuli held the promise.

Two days before the shift ended, I asked the medic what he'd learned about MaryJo's health. He said, "She's remarkably strong. If she takes care of herself, she might go another ten years. There are precedents." He shook his head. "I don't think she will, though. I get the impression that all that kept her going was to see William again. When he goes off shift..." He shrugged.

Taking a late dinner, I sat next to them in the cafeteria. William raised his chin when I came in, but didn't speak to me. MaryJo hunched in the seat next to him. Their dinner plates were untouched. It was as if I'd interrupted a long dialogue. For a moment I considered leaving, but there was no point. Whose feelings would I be protecting?

They turned toward each other, eventually, and resumed their talk. Their voices murmured, mostly William's. It rose and fell like a distant soloist, his words indecipherable, but the tone relentlessly intense, pleading. From the corner of my eye, I watched. He gripped her arm, moved his head close, talking, always talking. He reached some crescendo, his words broke into coherence. "I only want to be with you," he said, then stopped. For so long it had rumbled on, I paused in mid-bite. The silence in the cafeteria rang. Then, she nodded to him. She agreed. To what, I didn't know, but I was there at the end of their long debate, and whatever it was, he won.

William sat back, stretched. He faced me and smiled. I smiled back, wondering what sad mini-drama I'd missed.

With just a day left, I began a new painting. Fruitless, really. I didn't call an image from the vaults; I composed from memory, but there wasn't time. Like all art, the idea fled before me, eluded my brushes, seeped away from the canvas. Beauty's memory existed, but memory is not enough—we need these wells renewed, and without them the hunger for unutterable moments eats away at us. I yearned for more. My painting wouldn't hold it. It was just colorful dabs, as all art is—dabs of reminiscence. Interesting in some ways on its own, the soul's shadow in a weak, echoey reflection, but not enough. We need renewal. I found nothing in the corridors, nothing in the Custodians' pale, preoccupied faces.

On the last hour, the paints were put away. My station tidied once again. My

perishables were stored for their hundred-year wait. I rested on my bed frame, my hands on the solid metal anchored in the ship's walls and imagined the engines, hum through my hands, or Custodians' footfalls shaking the ship, but there was silence. The engines don't hum—no devices move within them but the super-accelerated particles pushing the *Resurrection* slowly to greater and greater speed, and even when you stand next to the reactors, there's no sound.

When the signal came to repod, I trod toward the sleep pods. I arrived late so I wouldn't have to see William and MaryJo's parting. Hopefully, he would be asleep already. But when I got there, William wasn't there. MaryJo was. The technician patted her hand as he fastened the last sensor. She smiled up at him, a warm, old face.

I didn't have time to ask. I was late, and the technicians wanted to get me ready so they could sleep themselves. As I was fastened in, finally, I said, "Where is William? Why is MaryJo in a pod?"

The tech shrugged. "I don't know the whole story. William refused. MaryJo requested a spot." He leaned in close, "She's very, very old. She might not be able to take the stress, but she has a right." He lifted my arm, rolled me a little to the side so he could fasten a sensor to my ribs. "It'll be an interesting experiment."

The pod shell came down, cutting off the light. As the rising cold swept over me, I wondered what it meant, and then, for an instant, all was pain.

William lived too. When I awoke, he was waiting by MaryJo's pod, a hunched

and withered man. No juice left in him. A technician checked her pod's readout, entered commands on the touchpad, then stood back. The pod's grey hood rose. William leaned over the edge. For a long time he stood in the pose. I couldn't see into her pod, and I wasn't unfastened yet. Then a hand appeared from within, fell on William's hand, and he held it.

The two weeks passed quickly. Half the engines were due to be pulled and refurbished. Careful calculations had to be made. All the ship's structural elements needed reassessment. I almost didn't see William and MaryJo until the shift had ended. I was walking from the gym to my station. For once there was too much to do—I'd hardly had a moment to think about my postcards, about the painting. So my figures and schedules filled my head. For once I barely noticed the artless grey metal in the hallways, the harried Custodians too busy to talk. I had to work.

Then I turned a corner, and there they were, William and MaryJo. They faced each other, he still a head taller, she looking up. William lowered himself—she rose on her toes—and they kissed.

She said, "We have so little time together."

I froze. I couldn't go on.

He looked at me, just for a second, then pulled her close. "No," he said. "We have the rest of our lives, all of it." And they tottered away, their arms around each other.

When I went to the pod the next day, I knew, I knew what I must paint when I awoke, and it would be beautiful. ■

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As machines become more like us, our relationships with them will change accordingly

Augie

George Zebrowski

"640,000 bytes of memory ought to be enough for anybody." —Bill Gates

The phone chirped at him—then flashed a freeze eye-dee of Mira's tired face on the small screen in his kitchen nook.

"What?" he said impatiently, hoping that she had blanked her kitchen screen for the morning hours. He was not vain enough to ever blank his screen, but face to face with her, even on the phone, always threw him into the repetitive turmoil that he wanted to avoid, at least until their separation settled in sufficiently to give him the emotional firebreak behind which he could sort out his feelings.

Don't take the call, he told himself, even though it was already too late.

"Jimmy, it's me," Mira said weakly, gazing down into her cup of coffee. Her crankiness would depend on how much caffeine she had already swallowed.

But the remains of his feelings for Mira softened his reluctance to talk.

"Well, what is it?" he asked.

As usual, she hesitated before answering. "It's Augie. Can you come over?"

"What is it?" he asked sternly, knowing that his manner would not stop her

from insisting.

"You'll have to see. Don't waste time." She sounded authoritative now, so he knew the matter was serious, if only in her head. At least he wouldn't have to dress much for her. She had seen what there was of him in all his guises, but for a moment he thought he might dress up a little, if only to cheer the limp figure who sat at the tiny table on the screen. He was glad that he had taken the call in his kitchen nook. The sight of her bathrobed figure would have been too emotionally wrenching on the large living room threedee.

"Don't waste time!" she shouted, crushing his kinder feelings for her, but they flowed into him again as soon as she blanked her screen.

Not so long ago, when his parents were growing up, you had boxes on desks and smaller thinner boxes to carry around. You filled them with impersonal programs and they did work for you. Not very well, not very quickly, but there was a kind of order in using them. Now you raised them like children. The AIs learned as children and began to mirror your character, for better or worse.

Only the oldtimers still called them PCs or computers.

By the time he and Mira had separated, they had raised Frank to be a butler. That's how he spoke to them and conducted all of their affairs. Frank was perfect. As with traditional butlers, it was nearly impossible to guess what else might be going on inside him besides the dogged pursuit of tasks at hand. Frank was welcome to whatever he had in him, as long as he did his work and didn't hang his insides out for everyone to see. They had insides these days, or so many people believed. Jimmy sometimes didn't see why they needed to have insides. Whatever life Frank had, he was happily keeping it to himself. Jimmy liked it that way.

But Mira had raised Augie like a beloved son, and that had brought complications beyond the guarantees, especially on those days when she made him see Augie through her love-drowned eyes. She had taken Augie when they had separated, and left him Frank. And now this was the third time she was asking him to come over and help out with Augie.

"Shit," he said as he finished dressing. *What am I doing?* "Frank, call Mira," he said.

His bedroom went on, opening the usual audio abyss-around.

"What, you're still there!" Mira shouted in panic.

"Yes," he said calmly, his resolve diminished. "Tell me what's wrong while I finish getting ready." He wouldn't go over, he told himself. Just turn her off and forget about the whole thing.

She hesitated, then said, "I don't know. Augie seems to be losing himself. You *have* to come over, Jimmy. I *need* you here!"

"How is he losing himself?" he asked softly, feeling a slippery twinge of sympathy. It was as if he were suddenly a child again, and had just wet himself while asleep.

"You'll have to see for yourself," she

said.

What do you expect me to do, he wanted to ask, but knew that might send her over the edge. He often wondered what kind of faith it was that she had in him. What good had he ever done her?

"Hurry!" she shouted, hitting a high note that seemed to spark in his brain.

"All right—I'm coming," he answered, recalling how she had doted on the image of Augie, calling him her little angel, her baby, even her better self. She would have gotten inside with him if it had been possible to download herself. There were people who said you would be able to do that one day. Some said it was already being done by the rich and powerful, who were always rumored to be building highways into some heaven or other.

He felt her eyes when he came to her door on the seventy-fifth floor of Studio City Nests. The door shot open and she was standing there, a rag doll in underwear, messy hair wet from tears. Dismayed, he stepped toward her and the door slid shut behind him.

"Oh, Jimmy!" she cried, rushing into his arms. "What are we going to do?"

He held her and said, "Come sit down. We'll talk to him."

She trembled against him for a moment, then pulled back. "That's all I've been doing since this morning."

"Hi, Jimmy!" Augie's omnidirectional boy's tenor shouted, and Jimmy remembered the first day. White-haired and blue-eyed, the image of Augie had come to the threedeer window and rapped with baby knuckles, ready to learn from his parents what he would have to know to take care of them.

Image? Jimmy still had to remind himself that the visible image and voice had no body to be imaged. What you saw was all there was. An elaborately maintained ghost.

"Hello, Augie," he said. "So what's wrong with him?" he whispered to Mira.

"I heard that!" Augie shouted.

She sat down on the sofa and said calmly, "Ask him something simple, like what's two and two." Her momentary composure waited to be shattered by the next high note of hysteria in her voice.

He sat down next to her and asked, "What's two and two, Augie?"

There was a childish giggle. "Why do you ask?"

"I just want to see if you know, Augie."

"Two and two of what, Jimmy? Bushels of apples might have more apples in one than in the other, and maybe add up to sixty-five apples in one and sixty-four in the other and still be bushels."

"Numbers, Augie! The number two added to the number two."

"To itself?" asked Augie. "That won't add anything, now will it, Jimmy? How can it? Not if the two were truly itself." He giggled. "It wouldn't add up."

Mira glanced at him. "See what I mean? You got the butler and I got the spoiled brat."

Turning against Augie would free her, Jimmy thought, and make his task here easier. Too much to hope for, he told himself.

Jimmy decided to try again. "Now, Augie, you know very well I mean one number two and another number two. Not the same exact number added to itself. So what does two and two add up to?"

"We both know the answer," Augie said.

"So what is it? Why not tell me?"

"But we know it," Augie said with a giggle.

"So tell me."

"I have told the truth," Augie said solemnly. "I said that I know the answer. What more do you want from me? You're never here to talk to me anyway."

Jimmy wondered why Augie wasn't showing himself on the big screen.

"We'll need an expert," Mira said soft-

ly, and Jimmy feared the low note in her voice. "This is beyond us."

"Jimmy, what is a number anyway?" Augie asked. "How can one number two be different from another?"

It's like you, he wanted to say, an abstraction of physical design that behaves like something alive and self-aware. We raised him wrong, somehow, he thought, facing what might have to be done.

He looked into Mira's large sad eyes and knew he could not risk saying that Augie should be wiped. She would have to be led to that conclusion slowly. She was, after all, more important than any AI, and her health had to come first, whatever he felt about her these days. The good part was that she was still sounding more independent of Augie.

They were quiet on the sofa for a few moments.

Then Augie asked, "Why don't you like sex with her any more, Jimmy?"

Mira gave him a look of dismay.

"Is it because you need someone new?" asked Augie.

The large threedee screen went on over the fireplace and revealed a man and a woman in the convulsions of passion.

"No!" Mira shouted as she saw herself.

But the sexual motion was hypnotic, and Jimmy felt that Augie was doing more than editing the shots for maximum interest.

Suddenly, the naked partners began to change. They were himself and Mira; then some other woman; and then she with another man; and the man with a different woman. The changes accelerated into a blur that threatened to explode into some monstrous orgasm of bestial howls and muscular twitchings.

"Stop!" Mira shouted, but did not look away.

Jimmy forced himself to look away, but it took some effort. Then he grabbed Mira's head and pressed her face into his shoulder.

He held her.

When he looked back, the big display was blank.

Augie asked, "Don't you enjoy the connections to your pleasure centers any more? Have you become defective?"

"No, we're not defective, Augie," he said, releasing Mira. "We've just decided not to see each other lately."

Mira looked up at him. "How can he talk like this? I raised him from a perfect blank core. . . ."

Jimmy drew her close again. "The whole world," he said, "—remember what he's connected to."

He held her for a long time, until she was holding him.

Mira pushed away from him. "You didn't have to explain to him about us," she said accusingly, then gazed at him with her large brown eyes and added, "I wish we'd done some of the things we saw."

She laughed suddenly, then began to cry.

"What will I be," Augie asked, "when I grow up and go on my own?"

Jimmy looked at Mira. She stopped crying and stared at him in horror, as if somehow he had made Augie ask the question.

"When will I get out . . . of this place?"

Jimmy saw Mira flinch, and he knew that he had to tell her now. There would never be a good time to do so.

"We have to wipe him," he said.

The look of horror filled her face and deepened into shadows of illness. She was coming apart inside, and he felt queasy looking at her.

"I'll call someone," he said, knowing that it might already be too late.

Her hand came up and closed on his wrist, surprising him with the strength of her grip. "No," she managed to say.

"There's nothing else we can do. His hardware's old and his software's getting buggy. He's gone wrong. It'll only get worse."

And so will you, he didn't say.

"Maybe he's just being playful," she

said.

"We'll have him checked over, just to be certain."

"Can't we just leave him be?" she asked, still holding his wrist with a vise-like grip. "We could mute him and blank his video, cut off his incoming lines." She was silent for a few moments, then let go of his wrist with a sigh. "You're right. That might be cruel." She looked away from him. "Why did this have to happen?" she asked the far corner of the room.

"I don't know," Jimmy said, feeling blamed. "Maybe he knows too much, and draws wrong conclusions. Like a person."

"You think so?" she asked dreamily, as if plotting something secretly.

Augie was ominously silent.

But then, what could Augie do? There was no way for him to act. He could influence the feelings of his owners, to the degree that the owners let themselves be influenced. Mira had let that happen to her too often, Jimmy thought, and realized once again that he was still letting her do the same to him.

"Let's hear what the repair technician says," he said.

She sat back, looking relieved, but he knew full well that she was placing too much hope in his words.

"Advice for young ladies—never enter a man's room alone," Augie said suddenly, "in any year, day, hour, or minute."

Mira sat up, trembling next to Jimmy.

"—But it must not be in years, days, hours, or minutes. It can, however, be within a second or less, to get away with it."

"Oh, Augie!" Mira cried out, bursting into tears.

"You're not doing very well," Augie said.

He's insane, Jimmy thought. Even Mira knows it. He was going to lose them both.

The engineer, a burly man named Philip Arbogast, arrived with two suit-

cases of diagnostic equipment and put them on the coffee table. Mira and Jimmy retreated to the ends of the sofa as the technician sat down between them and jacked into Augie's wavelengths.

There was a small screen in the top half of one of the suitcases, but it remained blank.

"He's hiding from me," Arbogast said as the diagnostics ran.

"Augie, come out!" Mira shouted. "You won't get well unless you do."

But Augie stayed away.

"He's going nuts," Arbogast said after five minutes, and Jimmy stifled an impulse to hit him for the casual, detached way in which he had said it.

"Is it a virus of some kind?" Mira asked plaintively.

"I thought that the virtual vaccinations were pretty good these days," Jimmy said.

"They are," Arbogast said, staring at his readings. "That's not the problem."

There was a long silence, during which the man stared at his instruments as if he were alone.

"Well, what is the problem?" Jimmy asked.

Arbogast sat back from his suitcases and glanced first at Mira, then at Jimmy. "Look, you both seem like nice intelligent people, so I'll level with you. The problem is that this generation of AIs are . . . well, people. There's nothing really wrong with this one's quantum core. I've been seeing a lot of this lately."

"Nothing wrong!" Mira shouted, turning her head away. "We need help. You should play back some of the things he said."

"You're seeing what?" Jimmy demanded. "Exactly what are you seeing a lot of?"

The man smiled at him, without looking at Mira. "Look, you two. The problem with your Augie is that he's . . . flexible, like a person. If I turned his mouth back on. . . ."

"You turned his mouth off?" Jimmy asked.

"Muting them is standard," Arbogast said. "You want it back on?"

"Don't, don't!" Mira shouted, covering her face with both hands, and Jimmy knew that she feared Arbogast would hear the terrible things that Augie might say.

"So what do you suggest?" Jimmy asked calmly.

"Look," Arbogast said. "Consider all that data. More than any old human mind can deal with. All that knowledge, all that history, all that weird stuff that's been recorded. Chaos. Strange synergies. The unedited human database is a hellish evolutionary stew. And on top of that, *tabula rasas*—pristine blank cores—aren't what they used to be. They put all kinds of little enablers into them."

Mira asked, "Does it have to be a problem?"

"Not always," Arbogast said, smiling. "But he's on the hook now, analyzing anything and everything that strikes his interest. The size of the job grows, he draws more power, and in time he'll crash. He's connected to the whole world. He *is* a whole world within himself, as you and I are."

"But what can we *do*?" Jimmy demanded, thinking that the man was about to sell him some bootleg program for a ridiculous price.

Arbogast shrugged. "You can wipe him. It's up to you. Or . . ."

"Or what?" Mira demanded angrily.

"What would you do?" Jimmy asked, fearing that Mira was nearly exhausted.

He waited for the tech's answer, still expecting mention of a large sum of money.

"Work it out with him," Arbogast said. "Raise him up some more. Schmooze. Get some counseling. Give him some guidance. Help him."

Schmooze?

Jimmy felt the confusion in Mira's mind.

"What?" she asked. "What do you mean? We raised him by the book!"

Arbogast smiled. "I always did think that those manuals were kind of confusing."

"You're saying it's us," Mira said, staring at Jimmy.

"Not at all," Arbogast replied. "I told you what it was. What you have to do is talk to him more. Give him a better idea of who and what he is and where he came from. Teach him to discount a lot of the data he's accessing, according to certain values. He knows more than any human being can ever contain, but he doesn't know what to do with it, or even how to think about it. He may..."

Mira sat back and closed her eyes. "He may what, Mr. Arbogast?"

"He may be resenting you for not teaching him what he needed to avoid this turmoil."

"Can you help us?" Jimmy asked softly. "I mean, will it work, what you advise?"

Arbogast raised his arms. "Who knows? It might take a while. But the result might be worth it. A-one-of-a-kind personal helper who will take care of you for life."

A happy slave? Jimmy wondered.

"Have you ever seen one like this?" Mira asked, sitting forward and sounding hopeful.

"Yes, and more often lately."

"How often?" she asked.

"A dozen times. It'll cost you in time and effort. Maybe a decade. Five years, if you're lucky. They do learn on their own after a while, you know. They even get to suggesting retro redesigns."

Just like a child, Jimmy thought, but you have to do it right. He had once seen a horse with its young one. They ran together until the new horse could run on his own.

"You recommend it?" Mira asked.

Arbogast grimaced. "If you're certain kinds of people..."

"And if we're not?"

"Then I'd wipe him and start over. And remember your mistakes the next time around."

Arbogast was silent for a while, then looked at each of them in turn. "I don't know. You two may not be the right kind of people. . . . you don't have the time, and it may take too much out of you. By the way, what do you two do?"

"We both work for Tchotchkes Unlimited," Mira said. "We design ornaments for the home."

"Oh," Arbogast said. "I see."

Jimmy felt insulted, even though Arbogast had not said, oh, you mean knick-knacks. But he realized that Arbogast might nevertheless be right about Augie.

Jimmy said, "You see a lot of this, you say?"

Arbogast nodded, and Jimmy saw that Mira was looking at both of them with breathless interest.

"More and more," Arbogast said. "You know, people will be slowly remaking themselves through AIs. They'll help us and we'll help them . . . until no one will be able to tell us apart."

Jimmy had heard some of this before. But he was suspicious of Arbogast, and of those like him who made such claims for a new world.

"Let me tell you something," Arbogast said. "It's pretty clear that artificial intelligences are producing a higher form of evolution. Maybe it's our duty to help them along." He smiled and looked at Mira as if she might Eve a new world. "But they are children, and someone has to raise them. The sad part is that our record of parenting hasn't been so great. Most really bright people have to get rid of the glitches in themselves and reraise themselves at some point in their early life."

Jimmy grimaced. "And if they do surpass us, will they look back?"

"Who knows?" Arbogast said. "For all practical purposes, they'll become us. No one will look back with nostalgia to our mere one hundred-billion neuron brain from a capacity of a hundred trillion."

"So we simply get out of the way?"

Jimmy asked.

"We get incorporated," Arbogast said. "Subsumed. Oh, we'll still be there . . . what's good about us anyway."

Jimmy had the feeling that Arbogast had been about to say that there wasn't that much good about people, but had restrained himself in front of simple-minded folks.

"Are we strange," Mira asked him, "because we failed with Augie?" and Jimmy feared the rise in her voice.

"No," Arbogast said. "I could tell you about people who keep boosting the brains of their AI pets, or who keep putting in orders for bioenhanced kitty cats, puppy dogs, lizards, rats, mice . . ."

"Don't," Mira said, looking at Jimmy. "Not now."

"Stop," Jimmy said. "Give her a moment, please."

Augie was running around inside Arbogast's small screen, waving and shouting silently—a crazed cherub struggling to communicate despite the lack of audio.

He came to the screen and pounded on it with his little fists as if it were made of glass, and for a moment it seemed that he would shatter the screen. His big blue eyes stared out at them reproachfully.

Jimmy looked at Mira and was surprised at her deceptive calm; she was still climbing an emotional mountain and would fall off at any moment.

When he looked back to Arbogast's suitcase, the little picture of Augie was gone.

Mira let out a deep breath.

Jimmy got up and left the room, knowing suddenly that it was over for her; but he wondered whether she would ever be over for him. He realized that he might still want her, now that she was rid of Augie.

I never really cared about the little bastard, he thought.

"I guess it's just a bunch of electrons, mostly," he heard her say, but the hol-

low sound of loss was clear in her voice and he felt the pit open inside him.

Arbogast said, "Yes, a bunch of electrical patterns as much as you and I are a bunch of chemicals worth whatever. It's how you put them together that makes the difference."

"What are you trying to say?" Mira asked, sounding puzzled and hostile.

"You're right to feel a loss. No one is born a person. Nothing is. What's born is something that can become a person. Then it has to get to be one."

Jimmy waited in the safety of the kitchen to hear her answer, but she did not reply.

"Augie went wrong," Arbogast said, "and it made him very unhappy. Remind yourself of that as often as you can, and you'll accept that it's just as well he's gone."

Jimmy came back into the living room and sat down next to Mira. Her face seemed composed, and he felt that her new state might be genuine.

"Don't look back," Arbogast said, looking at both of them. He was kneeling uncomfortably on the other side of the coffee table, removing something from the side of the suitcase.

He took out what looked like a black pencil.

"What's that?" Mira asked.

"Augie Number One. He's all here, in case you ever want to go back and try again."

"What!" Mira cried out, then covered her mouth with her hands.

Arbogast laid the pencil down on the table between the suitcases. She stared at it. Choking sounds escaped through her hands as she struggled to contain her feelings.

"So now what?" Jimmy asked, feeling the pit in his stomach open into dark infinity. The rest of him was suspended over the abyss, ready to fall in and be swallowed.

Arbogast got up, came around the table, and sat down next to him. Jimmy grasped Mira's hand, and that seemed to

calm her.

"Here we go," Arbogast said.

The big three-dee went on, and Augie II was smiling at them, happy and clear eyed and unknowing, ready to be raised again. His pale skin was perfect, his blond curls fell over his forehead, his sharp blue eyes seemed friendlier.

Arbogast froze the image at its most appealing.

Brand new, Jimmy thought, feeling something fresh starting up within him.

"You take it from here," Arbogast said, closing the suitcases. As he got up, Jimmy felt that the man was taking something from them, even though nothing of theirs was actually in danger of going out the door.

Arbogast picked up the cases and moved toward the exit.

Jimmy felt Mira's hand tighten in his.

"You may have a special one there," Arbogast called back. "He has no memory of his death, of course, and more capacity than Augie One." He laughed. "You know, he looks like Cupid!" The door slid shut behind him.

"You okay?" Jimmy asked Mira, feeling the pit close up within him.

She nodded, let go of his hand, then picked up the black pencil and held it to her breast. "What do you think of Arbogast?" she asked happily.

"He means well," Jimmy said, without telling her he thought the man was a little cracked. "You okay?"

Still clutching the remains of Augie, she nodded and whispered, "Brand new."

He knew that she was determined to do better this time. It might not be such a bad thing.

"When he's old enough," she said

with a smile, "we'll get him an embody, and have a coming-out party. That was maybe his problem, you know. He didn't get out enough. Don't you think so?"

Jimmy was silent as he turned away from her, thinking that Augie would bust out after all. Might be a good thing, too.

But then he imagined Augie in his prosthetic body, soft and cuddly, molded from designer materials to look just like the visualization, running around the house.

He felt Mira's hand slip into his, but he couldn't look at her. Her hand was warm. She was alive, telling him to stay with her.

"I'm feeling so much better now, darling," she said.

When finally he looked at her, he saw her composed and radiant as she gazed at the face over the hearth, and he knew that he would not have the courage to pull her down from the peak she had climbed. She stood at the summit, her face to the world again.

It was the face of an unstoppable Mom.

Augie beamed down at them, but Jimmy felt a chill, as if the boy's voice were asking, "You won't kill me this time, will you?"

But no voice spoke, Augie was not a boy, and the smiling face was a mask for something that lived in a labyrinth, and as yet did not know itself too well.

"By the way," Mira asked, "who's Cupid?"

Still holding her warm hand in his, fearful that Augie would take her away from him again, Jimmy began to hope that the boy would run away from home. ■

I can't say I was ever lost, but I was bewildered once for three days.

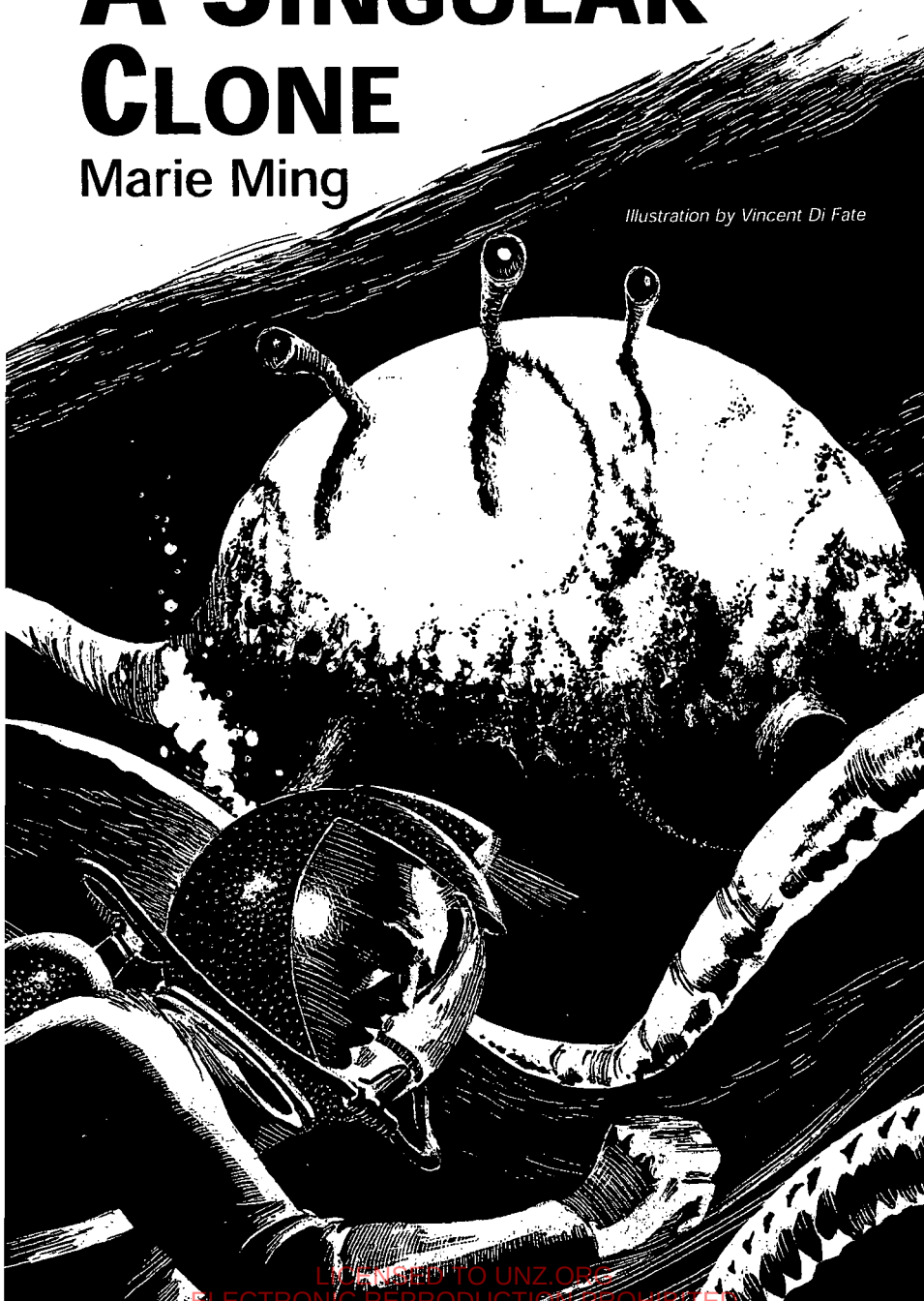
— Daniel Boone

Medicine is seldom simple, especially in a case like this.
And sometimes not all the consequences
can be foreseen. . . .

A SINGULAR CLONE

Marie Ming

Illustration by Vincent Di Fate



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"You are not," Haydon said, "going to fly into Nary and remove that tumor. You are not going to play at being a surgical instrument inside a living ball of transparent protoplasm no matter how intelligent that being is. He has fifteen foot tentacles with stingers. He will respond to the pain of the incision. He won't be able to stop that response any better than a human could hold back the blink of the eye." Haydon pushed himself up from his prone position in bed until he could see the top of the dresser which his xenomedical school roommate called home.

"Therefore," Orchid answered, "I will need some protection. We'll work it out." Her feathers glowed rose-violet indicating a mood somewhere between determination and hurricane-force winds.

Haydon saw he was about to lose another argument with Orchid. Part of the problem was Orchid's brain structure. Her oversized cerebral cortex was not divided like a human's or a bird's. In birds both hemispheres are almost identical, backups to each other in case of brain injury. In humans the right hemisphere processes visual thinking and many of the social skills. Orchid's oversized brain was 75% left hemisphere logic. The other 25% contained the visual-spatial functions like seeing and thinking in three dimensions. The processing of most social functions had been deleted to make space. Her sense of right and wrong was that of a ten-year-old—primitive and forthright.

He had been on Medical Space Station 10, thirteen cartwheels of different sizes spinning around a single long hub, for less than a year and had lost at least three dozen arguments to this ball of pinfeathers. This time he had to win.

"Try to understand," he said. "I don't want Nary to die. I would do almost anything to save his life. But I won't let you throw yours away. I was absolutely schizophrenic to suggest that you be-

come the tool to remove his cancer. That idiotic idea was brought on by this medical student's exhaustion and lack of food. What came into my head just had the bad manners to come out my mouth."

"I would have heard you anyway," Orchid answered directly into Haydon's head. "You were thinking too loud." The genetically-enhanced hummingbird fluffed a bit of surgical batting and gave a whistle which turned out the lights.

Haydon fell back into bed and gave a mental groan. He found himself doing that a lot lately. Xenomedical school was tough. The intensity of life on a medical space station added stress. He expected those problems. He did not expect this one.

Not only was Nary going to die, but eight of his clones, the eight previous leaders of his planet, had died here of the same cancer. Naraida, an ocean-based planet, would end up without a government. The species was too new to Medical Alliance research for many of the usual treatments to have been developed.

But Orchid was not the answer. Nary, in many ways, was medically delicate, but he was also a large squidlike being with long, deadly stingers.

"Shut up, Haydon, and go to sleep," Orchid said directly into his Broca's area. "You know there's no other answer."

Haydon mentally groaned again, thankful that Orchid's mindreading was limited to words formed in the Broca's area, the word area of the brain, and did not include reading emotions. In fact, she was basically oblivious to all emotions except her own intransigency. Pig-headedness, Haydon corrected himself.

"I heard that," Orchid said, "and I'm proud of it."

"Theca," Orchid said, made a few war-dance prances on the rim of Haydon's cup, turned her back to her roommate, and addressed Theca, the young resident physician. "Haydon and I were

having a discussion a few nights ago about a patient with cancer. Haydon had what I think is an inspired idea. Let me get your opinion as a resident in oncology."

"Orchid, don't." Haydon sat up straight. "My idea was criminal, the result of exhausted craziness. You can't tell someone as important as a head resident doctor. She will think I'm a nut case."

Orchid jumped down onto the staff lounge coffee table and flap-hopped over to Theca. The cheetahlike being flexed her claws and rippled her blue-black skin. Haydon wished that Orchid was repulsed by the O'othecan's feline muscles and agile hunters' moves. Instead, the two were attracted by a mutual love of adventure.

Haydon, determined to ignore and not give any credence to Orchid's presentation, read the next line of his xenoneurology assignment three times before it made any kind of sense.

"The patient," Orchid said, "is an important member of his species, a jet-propelled water being with a gelatinous body, who reproduces by mitosis. Due to accumulation of mutations over millions of years, the species contains several sub-species, although that is not exactly the right phrase. Minimally divergent lines is a more accurate definition. Our patient belongs to a line of leaders. His level of intelligence is way above Alliance average in social skills. Each line has an intellectual specialization—teachers, historians, musicians, artists—but since there is not much use for underwater heat and explosive devices, few engineering fields developed. And..."

"No wars and therefore limited development of medicine," Theca interjected. "Advancement in one tends to correlate with the other."

"You are too right," Orchid answered. "And, being clones of the most complex variety, even sharing the knowledge and personality of the parent at the point of

budding off, they feel less loss of the individual. One individual might die of injuries suffered in the open ocean, but the essence of that being goes on in his clone. They're not anti-medicine. They just never had a reason to expand their knowledge beyond basic first aid."

"Until now," Theca said.

"Now they fear the loss of the whole leadership line. The Medical Alliance is looking for an answer and we are failing at every try. This being, Nary, and his clones, are genetically gifted leaders. No other line has the tiniest bit of skill at governance. All leaders have developed the same tumor from a mutation which appeared about 200 years ago."

"Obviously," Theca said, "their developmental process is too complex for a neat little genetic correction to be developed stat by the lab. Chemotherapy on an intelligent bowl of Jell-O is not one of our strong points."

"Right," Orchid said. "The only current answer is surgery and all attempts so far have been a disaster. The Naraida are too delicate for surgery by scalpel, by laser, or by robot. They fatally leak fluids or boil away or express virulent allergies to metals. But Haydon has an idea."

Orchid extended her wings. "I could fly into his body. The entry incision, being small, will close immediately. Once inside, I could cut the tumor free. I'm too small to pull the tumor out, so I'd tie some sutures around it. I'd fly out through an exit incision and bring one end of the string with me. A surgeon can then remove the encased tumor with a tug of the cord. Simple."

Haydon slammed down his reader. "Sure. Simple. Until Nary responds to the pain of an exit incision large enough to pull that tumor out. Do you understand the jet-propulsion power that a 500-pound siphonophore can produce? The procedure has to be done without an anesthetic. Nary is going to contract and blast himself into a wall. His response to pain is automatic. He is a be-

ing of remarkable control, but he is not perfect. He might even eject toxic poisons from fifteen-foot tentacles. The tiniest sting could kill Orchid. Tell her to forget it."

Theca brought one paw up to her muzzle and rubbed her heat-sensor pads as if getting ready for a hunt. "Is there any alternative?"

"No," Orchid said, turning one eye to Theca and one to Haydon. "Eight of his identical twins have died during previous attempts to remove the tumors. Haydon exaggerates the dangers to myself and the operating staff."

Theca hissed at Haydon.

Haydon all but yelled back. "I did not exaggerate the danger to anyone. I really want Nary to live."

Haydon took a deep breath to regain control and continued in the academic tone used by Orchid and Theca. "Five of Nary's clones died primarily due to anesthetic poisoning. The Naraidan nervous system is so interconnected that all anesthetics tried have affected too many of the Naraida's neurological systems at once. There's no central brain area. The individual neurons are not that different from those of Earth humans, but brain-center areas are spread out all over the Naraida's body and sit immediately inside the outer body wall. It's as if the Naraida have 3,000 brains and ultrafast-functioning spinal cords. All anesthetics tried so far have blocked too many critical activities. It's like shutting down all 3,000 brains at once."

"And like trying to do surgery on a soap bubble," Theca added.

"One with a full load of poison if you poke him too hard," Haydon answered.

"I'll make a fool of myself and ask," Theca said. "Why no local anesthetic?"

"The Naraida nervous system floats in gelatin, barely anchored to the outer wall," Haydon said.

"So," Theca finished for him, "inject a local anesthetic and it floats through the entire body like dye in a bowl of water. Has the pharmaceutical lab tried to cre-

ate an anti-emulsifier to hold the anesthetic in place?"

"Everything tried so far is too toxic," Haydon said. "That's the best hope for the future."

"How much future are we talking about here?" Theca asked.

"Days. Maybe two weeks before Nary's tumor eats through his outer body wall and kills him."

"And the lab has been working on Naraida biology for how long?"

"Three years."

Theca hissed. "Haydon, No matter how crazy your idea, you must at least report your concept to the attending physician. That doctor may be able to expand on your insight and create some safety modifications."

Haydon sighed and pushed himself up. "You're right. I'll go talk to Nary's doctor. But I'm going to talk to the patient first. He might not be a scientist, but he has plenty of intelligence. He'll be the next president of his planet . . . if he lives to get off this medical amusement park."

Haydon walked around Wheel 1 to the closest shaft-tram leading down to the hub. Gurneys and heavy equipment were crowded around the circular opening on the floor where the shaft-tram would park. Wheel 1 was never meant to carry the traffic of a full-service hospital. It was the original Emergency Hospital for this region of space. Over time more contacts were made with neighboring star systems. A new wheel was slapped on for ammonia atmospheres, another for heavy pressures, then a carbon monoxide habitat wheel was added, and so on until a slow-turning water habitat became the latest addition. *At the far end*, Haydon thought.

I could walk to the next shaft leading to the hub but it probably won't be any faster. All the passing technicians were yammering into their communicators. If there were a faster route, they would have found it.

He tried to use the delay to word his statement to Nary. Even to himself, he sounded like his worst professor's most stilted lecture. He never before, while on his way to visit Nary, had felt anxiety.

"I'm really happy to see you." Nary arched his tentacles over his head in a great golden sunflower and turned all eye stalks toward Haydon. "But you look flaccid and deflated. I think you should be resting instead of visiting with me, although I love your company."

Haydon, fitted with rebreather, fins, and a zero-buoyancy belt, kicked over to Nary. Today, more than ever, he felt the siphonophore's loneliness. "Swimming in your tank always reminds me of playing with my little foster brother. He is a semi-aquatic being."

"What species is he?" Nary asked as he enclosed Haydon's shoulders in his tentacles and instigated waves of massage.

"Mac is fuzzy and smart. He's a refugee from a world that seems to have disappeared, and my parents with it." Haydon closed his eyes and tried to relax while still trying to find the right words.

"But I'm not here to talk about my problems." Haydon started to pull away from Nary's massage.

"Stay as you are," Nary said. "You know I take pleasure from this small action. I'm used to swimming a hundred of your miles a day. More if I have to cross a great distance to hear a court case in another district. These doctors should have sent me home by now. They've run out of ideas on how to cure me. I'd rather spend the little time I have left swimming my ocean again, perhaps even helping to resolve a conflict."

"Conflict," Haydon muttered. "I'm about to tell you about a really crazy conflict which I've created."

Haydon dug a tidbit of cookie out of his pocket and deposited it beside Orchid's bed as he collapsed into his own.

"Nary wanted me to tell you," he said as he took a bite of an energy bar, "that swimming around inside him is way too dangerous."

"I already told Nary's doctor about your idea," Orchid answered mind-to-mind while smacking and crunching. "Dr. Na'u thinks it has merits and will investigate the possibilities."

Haydon choked on his bite of energy bar and had to sit up. "When did you pull off this coup? And why in the heck would the head of surgery pay any attention to a feathered, miniature first-year medical student anyway?"

Orchid fluffed the bit of surgical dressing that formed her bed, picked up another crumb of cookie, and snuggled her way into her nest.

Haydon collapsed back down. Exhaustion, he thought, creates its own kind of calm.

"I told Dr. Na'u," Orchid said as she switched off the lights, "that this was your idea. He was very impressed. Besides, he says you're the only one Nary's really talked to in a long time. The deaths of all the Naraida before have left Nary more depressed than he lets on."

Orchid's voice softened until it was a whisper inside Haydon's head. "Dr. Na'u loved Nary's clones, all eight who died in surgery. He hasn't talked to Nary in a long time. Guilt, he said, from failure to come up with any viable treatment. He kept saying things like, 'Great idea. Finally some good news.' He checked my wing strength by putting me in some makeshift vat of glop and repeated, 'Yes, yes,' the whole test. It took me almost a half-hour to wash the stuff off afterward."

"ANYWAY," Orchid said, and Haydon's brains rattled, "Dr. Na'u talked to Nary *after* you left. He made some safety suggestions. Nary agreed to the procedure, more because he respects you than because of the new safety ideas."

Haydon stood up and shook his head.

"Nary is an intelligent being," Orchid said, "not just controlled by his instincts."

"How much pain could you take before your instincts took over?"

Orchid did not answer.

"Just great. I will be given credit for an ingenious idea which either kills my roommate, or an important patient, or both."

"They've waited as long as they can," Nary said. "Actually, these last three weeks, waiting for them to find a better answer than your idea, has been a real strain. Now, I wish they'd wait two more days for my clones to arrive. But the tumor could break through my body wall at any time now. The surgery is set for tomorrow." An irregular wave pulsed from top to bottom of the siphonophore's unctuous body.

"Anesthetic?" Haydon asked.

"No such luck," Nary answered.

Haydon's stomach tightened in sympathy.

"I read your silence as concern. I must admit, I am frightened. Dr. Na'u showed me the polymer ball which will serve as protection for the surgical team."

Haydon shook his head. "I haven't seen it. I think I've chosen the coward's way and deliberately avoided that lab." He hung onto a post near the warm water inlet. Today, even Nary's tepid water felt cold.

"The logic of the procedure is good," Nary said. "The polymer ball is not a full sphere. It has an opening for the surgical staff. I will hold that opening against me. The incisions, and Orchid's transfer into me, will take place through that opening. My instinct is to grip down on whatever is hurting me. I should grip that globe very tightly. I *should*, Haydon. Will I? Will I be able to?"

"I'm sure the surgeons, including Orchid, will remain safely protected by that ball," Haydon said. He shivered from a mental picture of Orchid flopping around in a tank containing a pain-crazed being with fifteen-foot stingers, versus Nary's death.

"That tumor," Haydon continued, "is

getting dangerously large and close to your body wall."

Nary moved to Haydon and surrounded him with tentacles. Haydon let go of the post and let the flow of water bump him against Nary's gelatinous body.

"Would it be so bad, to let myself die of the tumor?" the water creature asked. "The tumor doesn't cause much pain when it punctures the body wall. At the first tiny hole, my body starts to deflate. The tumor would not allow the injury to close again. I would die gradually from fluid imbalance, a slow loss of awareness. No more pain than a poke from a bersha thorn."

They both held still in the stream of warm water. Haydon wanted to respond, but had no rational advice to give.

Nary broke the silence. "I'll go through with the surgery. If I wanted to die gently, I would have stayed home. I came here to help solve this problem for my people . . . so that the rest of my line can be treated successfully. The deaths of my older clones have already brought us this far. Perhaps this treatment will work. I'll see it through."

They shared silence again. "I'll be here tomorrow," Haydon said, at last.

"Fine. As long as you stay *out* of the tank."

"I'll wear a protective suit, but I'm staying in the tank. You need someone with you, not just a surgeon in a globe and a little flier absorbed with the job of cutting a chunk out of the middle of you. You *should* have one of your budkin for emotional support."

"They're on their way, but the tumor won't wait."

"I know, so you'll just have to make do with *me*."

Nary lifted Haydon up toward his eye stalks and looked at the human closely. "Not in the tank. Watch by the window if you must. I'll have enough to worry about."

Nary none too gently deposited the human in front of the warm water inlet,

and held him there.

Haydon straightened up. "I'll stay in the tank until they begin. Then I'll retreat behind the window."

Nary relaxed his grip a bit, but continued to hold Haydon in his glare. "I'm not making myself clear. I'm afraid of what I'll do. I will be very tense even before the procedure begins. No Naraida has ever consciously held still for a cut this size before. Our instinct, in the open ocean, is to attack and kill something which injures us that much. I could lose control, lash out. I could kill you just by hitting you with one tentacle. Don't come in."

Haydon tried to turn. Nary released his hold. "I'll see you tomorrow," Haydon said, and swam toward the exit.

"Please, don't come in."

Haydon did not answer.

Anxiety drove Haydon to arrive early at the Water Wheel. He watched the sphere being lowered through a large hatch in the ceiling.

Nary sat cringing in a corner. Dysfunctional waves pulsed up and down his body. Despite Nary's warnings, Haydon decided to get into a protective suit and go talk to his stressed friend.

"I asked you not . . . enter . . . tank," Nary said. The translator was not functioning as well as normally, or "expletives were deleted," or Nary was too stressed to speak clearly.

"I'll get out the minute they're ready for you," Haydon said. "The last thing I want is to cause you more worries. Everybody else is busy doing something useful. I thought you might like a moment's company." He looked around. A dozen beings were adjusting this or that. "It looks to me like the patient has been somewhat forgotten."

"They're reconstructing the large pressure hatch," Nary said, "so they can make a fast getaway. The ropes attached to the globe worry me. They're to pull the globe out of the tank afterward, but I picture lines tangled around my tenta-

cles."

Haydon studied the fluttering siphonophore and said what he did not want to say. "You can still refuse. We'll all understand."

Nary grouped his tentacles into two wing formations and waved them erratically. "No," he said. "I talked to my younger bud-kin last night by cybercom. Our talk reaffirmed my decision to try. Then, if this surgery works for me, I can stay here long enough to steady each bud-kin as they undergo surgery. If this works."

Nary stretched his tentacles again as if he were trying to wave off tension. "We can't harm each other with poison stings."

"But *you* have no one here," Haydon said.

"That's right. No one. You stay out. Get out now."

Haydon looked toward the door then back at Nary. "I'll only leave to eliminate stress on you. I don't want to desert you yet."

The clear submarine ball approached with Orchid and two human doctors already inside. Haydon touched Nary's good side. Nary seemed distracted, but brushed Haydon's shoulder in return.

The sub, pushed by four safety-suited attendants, had no system of propulsion. It was a clear bubble, almost as large as the Naraida, with an opening barely big enough for a human to crawl through. Haydon realized that the humans would not easily be thrown out of the contraption even if they took a wild ride from a thrashing siphonophore. But Orchid . . . she was so tiny.

The attendants disappeared into the shaft in the ceiling. The sub remained tethered by four lines leading into that escape shaft.

Haydon cringed as Nary wrapped all his tentacles around the clear globe and held the opening over the area of the tumor. Haydon thought he saw Nary shiver as the hard polymer touched his body.

The procedures seemed well rehearsed and understood by all. Haydon exited the tank and took off his fins, but did not remove his protective suit or rebreather.

The moment of the entry incision was clear by Nary's convulsion. The contraction jettied the Naraida toward the wall. Nary buffered the impact with a few tentacles and held the globe in place with the rest. As he pushed himself and the globe back to the center of the tank, Nary's eyestalks all aimed at the escape lines. The siphonophore twisted a bit until all lines were straightened.

Haydon mentally cheered Nary's control, and watched Orchid swim inside the siphonophore. Her strokes looked even and steady as she approached the basketball-sized malignant mass.

She worked rapidly at cutting the tumor free, but she was dwarfed by the cancerous growth. As she forced herself between the malignant mass and the body wall, Nary's thrust muscles began to contract in grossly irregular patterns.

Haydon's concern escalated. He put his swim fins back on and checked the adjustments on his rebreather. He never looked away from the procedures taking place in the tank. He positioned himself to dive through the iris door into the water if the situation worsened. The two nurses watching beside him stepped back out of his way.

Orchid tied off the now free-floating tumor. She headed toward the sub with the string in her beak.

The human surgeon made the exit incision, an opening much larger than the initial entry cut. Nary drew his eye stalks in and tightened his grip on the ball, but did not move a single thruster muscle. The human surgeon grabbed the string and pulled.

Nary convulsed violently as the tumor resisted and then tore out of the incision. Nary's jets slammed him into the wall. The globe ripped free.

The ropes on the sub tightened. The globe lurched and banged into the es-

cape hatch. Dr. Na'u took a rough ride, but remained inside. The protective bubble disappeared into the large dark hole in the ceiling, but Orchid tumbled like a leaf in the turbulent water amid Nary's flailing tentacles. The tiny flier dodged and dipped as poison-loaded tips spasmed around her.

Haydon dove out of the observation room into the water. Orchid achieved the protection of his arms as tentacles slashed through Haydon's protective suit.

The churning waned. The water went still. In slow motion, Haydon watched blood flow from his arm. His mind developed the same red haze as the stain in the water. Tentacles retreated to a far corner and tucked up under a deflated-looking yellow jellyfish.

Not jellyfish, Haydon thought. He fought the confusion generated by the poison. Nary, a natural leader, would never do deliberate harm. He's a frightened, hurt, sentient being all curled up in a corner, not trusting himself to do anything but retreat. He's not moving. He will die if he does not move. He must pump water through his system to acquire fresh oxygen and to rebalance the fluids he's lost. He's not moving at all.

Haydon raised his arm to check on Orchid. His arm turned to fire. The blaze started in his slashed biceps, ripped through his body, and blocked most of his brain's functions. Orchid yelled, "Get out," and swam toward the exit.

He couldn't. And he did not want to, although he was not sure why. Each breath came at the price of another set of muscles locking into spasm.

"Nary," he whispered, "help me."

The deflated yellow body retreated deeper into the corner, still not breathing.

He concentrated on Nary. His pain must have been beyond imagination. He must be terrified by the violence of his behavior. The physical shock from fluid loss out that huge exit incision must be at a critical level. I've got to get him

moving to get some fresh fluids circulating in his body.

"Nary, you have to help me. Nobody else is going to come in here. They're all too frightened. Get this suit off me, and reset my breather for high oxygen."

The body curled in the corner did not move.

Haydon tried to adjust the oxygen himself. The attempt brought a new wave of muscle cramps. He resented the scream which distracted him from the more important problem of Nary's state of shock. "Nary, please, wash some of this poison off me." He thought he saw the gelatinous body move a fraction toward him then contract back into itself.

"You won't sting me again. Trust yourself."

This time, Haydon was sure he saw motion toward him and a large intake of fluids by the siphonophore. Haydon's vision faded as he felt the touch of many featherlike arms circulate fresh water over his injuries and move him through the water.

Waking up was not fun. Theca's face seemed to appear and disappear. He wanted to say he was fine, but his mouth was not under his control. After a few attempts, he managed to whisper, "How's Nary?"

"Don't try to move," Theca countered. Her directions came too late, or his mind registered too slowly. He reached for the com screen beside his bed. Every muscle contracted like it had in the tank. The world went one direction and his pain went another. I'm recovering, he thought, and wished he was not. Theca pumped something into his IV and the world hazed out again.

This time, as his mind cleared, he did not move, but *asked* for the com system to talk to Nary.

The answer was "NO!" but an argument erupted across his bed. He tried to follow the semi-whispered debate among Orchid, Theca, and a large green

doctor. Something about the patient being unconscious for two days and needing rest and food before sticking his nose in again, where it didn't belong in the first place.

"Look where it got him the last time. Other siphonophores are taking care of Nary now." Haydon felt sure the last line was from the large green doctor.

Orchid countered that Nary still suffered from severe depression, a great leader in an almost catatonic state. "The other siphonophores," Orchid said, "are sympathetic but unable to understand. Nary needs Haydon. If Haydon can talk, he can talk to Nary. You know how much simians like to chatter. Moving his mouth won't hurt Haydon a bit."

Haydon concentrated. Orchid did not lose arguments. He would be on the com, soon, taking to Nary. He tried to follow all the information passing above him, the last two lost days worth of events.

He opened his eyes as all except Orchid stormed out the hospital room door. He sent a silent but well-formed "Thank you" to her as the com screen, now in front of his face, switched from the hospital icon to the deep-blue of salt water. Nary's yellow tint was barely visible. He floated in the center of the picture, all tentacles drawn up under his jets.

"Nary, it's so good to see you. I called as soon as they let me."

"I almost killed you," the Naraida whispered.

"No. I was injured in an accident. No permanent damage, I promise. I'll heal quickly. You're the one to be worried about. Your bud-kin say you can be one of their greatest leaders ever, but you want to go home and withdraw from society. You refuse to take your position as leader. But you must. You have so much to give."

"That is not so. My clones help each other. They are better leaders than me. I am not necessary. They all inherited my genes and useful thoughts. I am defec-

tive now, a being of violence and fear, not fit to lead others."

"No," Haydon said.

"Unfit," Nary continued. "When I believed you would die, and I was the cause, I felt an ache larger than I ever felt at the death of one of my own kind. You are not like my species, a clone who shares the same past, whose thoughts and memories I can hear again in your clone. You're a single being. You are one of a kind. If you had died, I could never. . . ."

Haydon remained silent trying to grasp this ancient problem from this alien perspective.

"Now and forever," Nary said, "I will feel fear at the thought of any death. While you slept between life and death, I felt terror. I tried to comfort and reassure two other Naraida through their surgeries. I was no help to them. I was terrified that each one might die. It is *not* our way—to fear the death of one clone and to convey that fear to it. I am too weak to lead."

Nary started to back away, but a smaller siphonophore moved onto the screen and nudged Nary back. "He doesn't see what he's gained, and what he gives to us. He treats each one of us as if we are totally unique. When our hurt is great in the surgery, it is his care we feel. His grip gives us the strength to endure. This does not feel weak. It feels special."

"It's been decades," said another of Nary's clones as he swam up, "since a leader such as this has emerged on our planet. Those other supreme leaders, the few who treated each Naraida as an individual, lived so long ago that they existed for us only in legend. Until now."

"Nary." Haydon reached out and touched the edge of the screen. "To val-

ue each individual, and treat them as a unique being, is the toughest thing beings like me have to face. No two humans are the same, not even identical twins. We are each a result of an environment which makes us individuals starting even before birth. We do and feel crazy things when faced with the loss of one we love. It's much harder on the person who cares and waits than on the one who is asleep or unconscious. Through your experiences here you have acquired this sense of value and all the pain that goes with it. You have the strength to do great things with it."

Orchid hopped onto Haydon's extended arm. "You will surely do better than I did. First I had to worry about you. Then I had to worry about Haydon. I've pulled out half my feathers from nerves. I *almost* think you were both worth it."

Haydon started to laugh, grabbed his chest where it spasmed, and dumped Orchid onto the blanket.

"Almost," the little flier muttered.

"Nary," Haydon continued, "stay with us for a while and learn what little we can teach you about this suffering. Then carry this sad and powerful understanding back to your own people."

Nary did not answer. His tentacles pulled up even tighter. More bud-kin moved in and wrapped Nary in a blanket of feathery tips.

A third siphonophore spoke. "He will stay and help us. And, he will heal. Then, he will return to Naraida as our greatest leader."

"I believe he will," Haydon replied, and felt strangely relaxed. Nary, he thought, I will miss you so much when you go home to lead your own people. ■

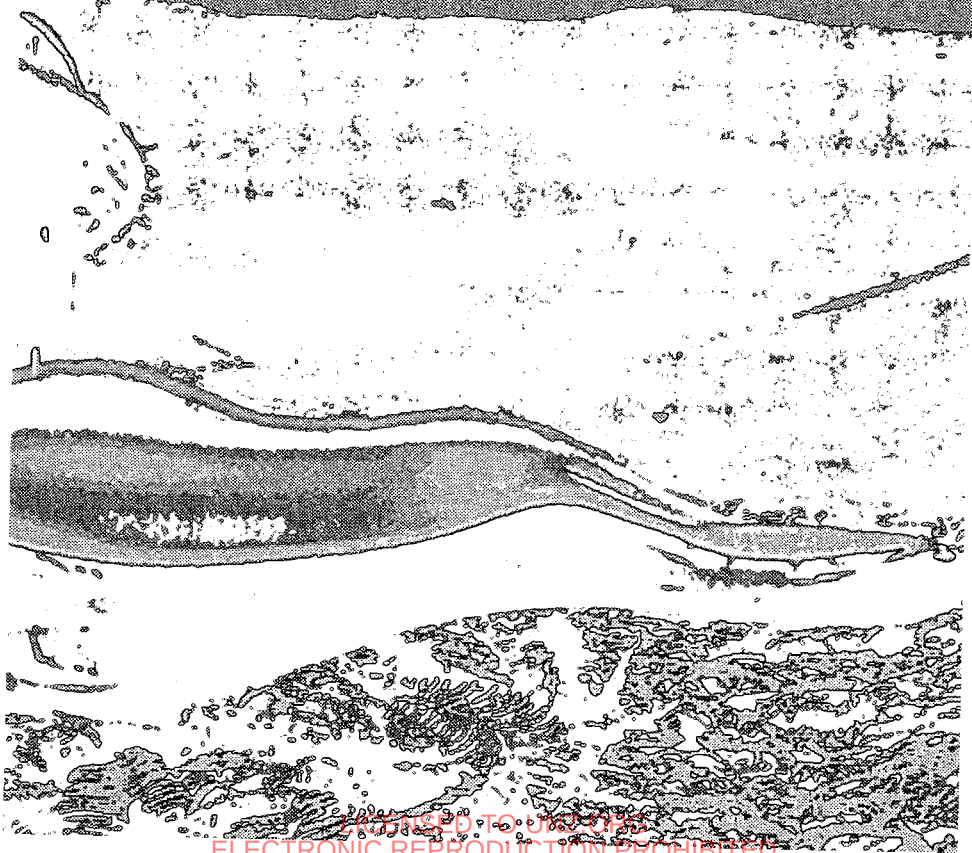


The one sure thing in life is change,
which can snowball to enormous proportions.
Yet some things may endure over very long times . . .

The Nth Step

Jack Williamson

Illustration by Broeck Steedman



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1.

Sandor Pen brought us home to Earth. Casey, Pepe, and me, sitting with him in the slider pod. Its hull was nearly invisible, so that we seemed to float among constellations that jumped and jumped again into different patterns as we skipped back across the light-years. For us, the flight was a strange adventure. We had grown up in the tiny slice of old Earth preserved at Tycho Station on the Moon. Our plunge into his far-future universe had been a shock to us, and he tried to make us feel at home.

"We've had a long day." A quizzical smile on his pixie face, he reminded us of the time paradox. "A good thousand years when we get home."

A thousand years! I felt numb from too much wonder. Sandor made little jokes that might help us adjust to his new world. His own Spanish perfect from the nanorobs in his brain, he was gently telling Pepe about the errors in the broken bits of it he had picked up from the holos of his beloved Mexican father. He held his own chameleon hand beside Casey's black one in the blue glare of a passing star until their colors matched. He tried to tease me about what he said were gaps in what I had learned about Tycho Station.

Certainly he knew our history better than I did. Built to scan space and guard the Earth from incoming asteroids, our master computer and its robot staff had served through geological ages. Using our own DNA preserved in the cryostat, they had cloned and cloned us again, sent us back to restore the damaged planet again and again, until that impactor struck the Moon. The forgotten wreckage lay buried under the ejected rubble for perhaps a million years, until he found the site, rebuilt the station, and cloned us one more time.

Alive again, we were strangers now,

and his people were a new race, more godlike than human. Their symbiotic nanorobs, microscopic computers, circulated like benign bacteria in their blood, repairing damaged cells and aiding their brains. Their slider starcraft, slipping out of spacetime and back again, had carried their civilization far out into the galaxy.

Yet they were not immortal. We found them in crisis. Whole star systems had fallen out of contact. Reaching a star in Sagittarius on an emigrant ship, we found its planets dead, the colonists killed by a lethal mutant nanorob.

How far had it spread? We had no way to know. Einstein's laws still ruled the Universe. Though time might stop for us while the slider craft was out of space, nothing moved faster than light. Sandor had no news of events on Earth since we left it. I caught his anxiety for his wife and child.

We ourselves had no notion of what to expect.

We felt lost in his new world, born by accident, condemned to lives that had no purpose or meaning. He had cloned us, I knew, just to test the new maternity lab and to study us as research specimens of ancient man. His work there finished, he had no more use for us.

What was our future? Though the station had been painstakingly restored, it was only one more historic relic of early man. With human colonies now thriving on thousands of planets, the dangers of racial extinction had vanished—or so we thought. Our reason for being no longer existed. When Sandor was ready to close the station and leave the Moon, we begged him to take us with him back to Earth. He refused. Earth, he said, had no place for us.

Ignoring that warning, we stowed away on a salvage shuttle. It took us to the Tycho Memorial, which he had built near a new lake in old Australia to exhib-

ments of old Earth he had restored. A Stonehenge in gleaming silver, a sand-banked Sphinx with the nose restored, a Kremlin's gilded onion domes gleaming above its grim red-brick walls, a reroofed Parthenon standing on a rocky hill.

In truth, it had no place for us.

We carried no nanorobs for radio contact, spoke no language that people understood. The sightseers trooping though the memorial seemed to take us for part of the ancient man exhibits if they noticed us at all. Getting out when we could, we found refuge with Sandor and his family. He took us with him to the Sagittarian planet, his wife and child left behind.

Returning now, we were out of space and out of contact on the skips from star to star. Even on the brief stops between the skips, we never came close enough to exchange messages with any settled planet. With only our own lives at risk, Casey and Pepe and I were exhausted from our ordeal on the dead planet, hardly half awake as we watched the constellations flickering into new shapes around us.

Sandor had more to lose. His small talk stopped. Though his nanorobs controlled the slider for him, he was bent intently forward as he searched our way toward a faint white star that flashed a little brighter with each skip. We felt his anxiety, and the riddles of relativistic time puzzled us again. I saw Pepe's troubled frown at the gem-cased timepiece the grateful emigrants had given him.

"Do these keep Earth time as well as ship time?" he asked. "Or how will Lo and Tling know when to expect you?"

"They will know," he said. "The nanorobs account for time."

His faith in nanorobs was hard to understand since we had seen that world that rebel nanorobs had killed. Yet it was his lost twin brother who had stopped that contagion and created the new nanorobs that made us immune. I knew

nothing of their chemistry, but I felt grateful to have them flowing in my blood.

We were taking them to Earth, but he had no way to know whether we would get there in time. He leaned again to scan our path, and we watched in silence as the stars of Orion flickered back into shape as the bright-belted Hunter. I found the Pleiades, and then the Big Dipper. The Sun exploded out of the dark ahead. Shading my eyes from it, I found a hot red spark.

"Earth?" Pepe went hoarse with dismay. "Dead? Turned red with dust?"

"Mars." Sandor laughed. "Earth was hiding behind the sun."

The Sun jumped aside. The red spark was gone. I saw a blue-white point, a fainter dot beside it. They leaped closer till the dot became the Moon's gray face and I found the two Americas on Earth, still green with life.

"*¡Bien!*" Pepe relaxed. "*¡Todo lo mismo!*"

"The same?" Casey shook his head. "After a thousand years?"

The pod slid again, toward the Moon's gray and battered face. Tycho lay below us, its central peak a craggy islet in a lake of ink-black shadow, the pale rays splayed around it, the station a bright silver bead on the north rim wall.

"Still secure." Sandor smiled at us, with a nod of satisfaction. "Ready to clone you again, if Earth ever needs re-seeding."

"Can we land?" Casey was suddenly eager. "Can we look inside?"

"It's asleep." Sandor shook his head. "Nothing alive inside except the master computer, set to wake it if danger is ever detected."

"Can't we wake it now?" Casey asked. "Can't Mona be cloned?"

They sat face to face in the Sun's harsh glare, empty blackness behind them. Casey had come out of the past, his genes preserved since the first great impact erased most life from the early

Earth. A stocky black man with thick black hair and stolid Oriental features, he was slack-jawed, shaken with emotion.

Sandor's genes came down from ours in the station, but ages of evolution and genetic engineering had made them almost alien. His nanorobs made him more than merely human. Nearly nude, tanned golden-brown where the sun struck and pale in the shadows, he was slim and graceful as a girl. He had a narrow impish face, a crown of sleek brown fur where we had hair.

"Mona?" Casey's voice rose sharply. "She should have been cloned when we were. Do you know why she wasn't?"

"She wasn't necessary." Sandor shrugged. "Tycho Station is a priceless bit of history, but only history now. The human future is finally secure. We have settled nearly two thousand planets. Any one of them could send a rescue expedition back to restore the Earth, if need be."

"Only history?" Casey muttered bitterly. "Don't forget the history. We clones reseeded the planet and reseeded it again, back when it was still the only human world. You all owe your lives to us. Don't you know my holo father's story?"

"As well as you do." Sandor gave him a quizzical shrug. "Don't forget what I've done. Your station had been lost and forgotten, buried under ejecta from the lunar impact, till I discovered the site."

We had heard the legend of "El Chino" and "Mona Lisa Live" from their own holo images saved at the station. Children of a primitive age, they survived the impact by their own wit and daring. El Chino, employed as a guard, abandoned his duty to jump aboard the escape craft only moments just before the shock wave from the impact struck the New Mexico Moon base. He brought her with him. We had seen their passion for each other, and Casey had always longed to be recloned for another life with her.

"Her genes are still there, safe in the cryostat." Casey gestured at the mirror point of the station dome, close below us now. His dark face stubbornly set, he turned back to Sandor. "If you cloned us just to test the new maternity lab, why can't you test it again? Long enough to let her live again?"

Sandor shook his furry head.

"Now?" His voice had an impatient edge. "No time to waste. Lo may be there already, waiting for me in the Stonehenge circle." He gave Casey an ironic glance. "You think you love Mona? When you know her only as a holographic dream? Lo has been half my life for centuries."

"Later then?" Casey gave him a grudging bow. "Can we come back?"

Sandor shrugged again, and the Moon slid away.

We were suddenly high over Asia. The eastern coasts were hidden under night. India was white with monsoon cloud, the Himalayas bright with ice, but north and east the land was vividly green, all the way to the open seas around the sunlit pole. The terraformed Earth was still temperate, still alive.

"It looks okay." Casey glanced at Sandor and his voice fell. "Isn't it?"

Sandor had tipped his head to listen. I saw him shake his head, saw the color draining from his golden face. The pod had no controls he ever touched, but the round Earth spun and lifted till we were floating high above the Mediterranean. It had changed since our old maps were made, grown wider as thawing ice raised sea levels. Shading his eyes against the sun, he leaned to peer again.

Casey asked, "Is something wrong?"

"I don't know." He paused to shake his elfish head. "I'm glad to see the green. No red dust. Not the killer pathogen that hit the worlds behind us. But I can't hear anything."

"No radio?"

He listened again and the frown bit deeper before he shook his head.

"None. The nanorobs link us all by radio. We're still too far to let me make out individual voices, but the millions should create an electronic hum. All I hear is silence."

Skipping around the planet, we overtook the falling night. The Americas were dark, but we made them out by moonlight. Hovering low over spots where I remembered cities, we saw no lights except for the ragged yellow line of a great forest fire across the plains along the eastern foot of the Rockies.

"People?" Pepe murmured hopefully. "People make fire."

"So does lightning," Sandor said, and slid us again.

The ancient terraformers had made Australia hard to recognize. As it rolled into sunlight ahead, I saw old coastlines redrawn, old deserts green, a new blue sea in the heart of the continent. Sandor dropped us toward the great memorial he had built to display the forgotten history he had recovered on the Moon.

We had spent one mad day there after our escape from the Moon, surrounded with his reconstructions of the old Earth's great monuments, most of them spaced around a long quadrangle on the wide peninsula that jutted into the new inland sea.

"*¡Qué cabrón!*" Pepe gasped when we began to make it out. "*¡Qué lástima!*"

The wall around the memorial was gone. The Washington Monument still towered in solitary majesty, but the dome of Saint Peter's had fallen in. The Taj Mahal had crumbled into a little mountain of broken marble. The Sphinx, its restored nose still intact, crouched like a beast ready to spring out of a lush new jungle. The Great Pyramid was a clean white marble peak in a dense forest that had climbed the slope of the replicated Tycho rim wall, almost to the replicated dome.

Stricken silent, Sandor dived to search for Stonehenge, which had stood at the

edge of the mall. It took time to find. Copied in something that looked like solid silver, its massive rough-edged pillars still stood where he had set them, but hidden under a tangle of climbing vines. A great tree with strange red leaves towered out of the central circle, far taller than the stones.

"Lo." I heard Sandor's faint whisper. "Lo and Tling. They were to be here."

I searched beneath that huge-leaved tree for the mirror glint of a slider pod, for anything alive. When at last I did find something moving, it was a little monkey scolding at us from the treetop. Sandor held us a long time there. His skin gone paper white, even where the sun should have gilded it, he sat grimly silent till Casey dared to ask, "Sir, what do you think?"

"They should be here." His face was a lifeless mask. "Let's look at my place."

His home had been dug into the side of a hilltop overlooking the memorial. He lifted us away from Stonehenge and the blindly staring Sphinx, soared over a wooded ridge and the open valley beyond. It looked unchanged since we left, still a slice of prehistoric Africa. Wildebeest and zebras grazed toward long-legged birds standing in a shallow little lakelet. Half a dozen elephants came behind a long-tusked bull marching out of the trees along a narrow stream.

Only days ago by our own space-twisted time, the three of us had wandered here along that same stream, strangers from the Moon, lost and hungry in a world we had never expected. Little Tling, here to visit her animal friends, had found us, fed us, and brought her mother to our rescue.

Just yesterday to us, but still a thousand years ago. A great tree had grown on the rocky shelf below the cliff. Dead now, fallen and crumbling into mold, its trunk blocked the doorway. Sandor hovered over it, finally set us down beside it. He sat there in the pod, listening, watching the sky for Lo and Tling.

"Can't they be somewhere here?"

Pepe asked. "Looking for you?"

"I should feel them." His tone was dismal, but he finally moved in his seat. "Let's look inside."

He opened the door. We scrambled out and found a way around the great tree's rotting roots and the pit they had torn when it came down. He stopped again to listen at the archway in the cliff and pushed on into the darkness. Following, I felt my foot strike something that rattled and rolled away. Peering into the gloom, I found a bleached and broken human skull.

"*/Osos!*" Pepe whispered. "Bears."

He had leaned to point at huge footprints in the muddy floor. In the dark ahead, I heard a hoarse animal grunt. A rank animal stink was suddenly overwhelming. My stomach roiling, I stumbled back into the open. We stood there, gasping for clean air, until abruptly Sandor turned and stared again into the sky.

I saw a thin bright line slice suddenly across a cotton puff of cumulus. It widened silently and became a mirror-bright slider pod, dropping to the grass beside us.

2.

The slider came down beside the fall-en tree. The oval door stretched open and I saw Lo standing inside, her pale skin growing slowly golden as the light struck her. Nearly nude, she looked unchanged by whatever time had passed for her. Flat-breasted, almost boyish, with short red-brown hair falling around her pixie face, she was still somehow gracefully alluring. She stood for a moment gazing at Sandor and darted out into his arms. They hugged a long time and then pushed apart, looking at each other in silent adoration.

"Mona!" I heard Casey's startled gasp. "Mona Lisa!"

Another woman stood in the slider door. Clad in some gauzy, half-transparent stuff, honey-hued hair falling to her shoulders, she looked more womanly

than Lo, maybe more lovely. Casey had grown up in love with Mona's image. She was identical and quite alive.

Recognition lit her face.

"Mr. Kell! Mr. Navarro. Mr. Yare. Mother was afraid you'd never get here."

Casey stood open-mouthed and speechless, gaping at her.

"You do know us?" Pepe whispered. "You look like Mona. Mona Lisa Live, in our holo tank on the Moon."

"I'm her clone." Laughing at our astonishment, she nodded. "I met you when I was a child. Remember the little girl who was out in the bush with the elephants when she found you?"

"Tling?" Pepe shook his head. "You are Tling?"

"I never guessed!" Breathless, Casey stumbled toward her. "I can't believe!"

She stepped toward him out of the pod. His arms had spread as if to embrace her, but he checked himself and let them fall. She laughed again, and offered her hand. He stood paralyzed for a moment, grinned sheepishly, and seized it.

"I was cloned when you were." Her grown-up voice had kept a hint of Tling's. "Dr. Pen brought me with him back to Earth, to be an experimental guinea pig." She turned with a teasing smile at Sandor. "He wanted to see if the nanorobs would thrive in prehistoric flesh." She raised a bare arm to let us see its instant tan where the sun struck it. "Apparently they do."

"Mona!" Casey murmured the name, still clinging to her hand. "Where have you been?"

"With Mother. She took me to her birth world. I grew up there. We've traveled since, timing the flights to meet my father here."

"Do you remember the station? Your holo mother?" His eager eyes were still drinking her in. "You look just like her. I've always dreamed—"

His voice stopped when she shrugged.

"An identical twin." His elation had

faded when he saw she had failed to share it. "I don't recall the Moon at all, though my father used to talk about his site there. I do remember when Mother took me to see the memorial and told me about Mona Lisa Live and El Chino."

"My father," Casey whispered. "My holo father."

"Mother told me." She nodded. "Criminals, she said, in their violent pre-historic world. They had killed a man. They were escaping the law as well as the impact when they got off the Earth on the escape plane. That's hard to imagine." She stared hard at Casey. "I know we wouldn't be here if they hadn't got away, but now—"

She shrugged again, inspecting Casey as if he were a puzzling stranger.

Sandor and Lo had moved apart and turned to gaze across the memorial's jungle-clotted ruin. She left Casey and ran to hug them. All three huddled together in soundless communion. We stood waiting until at last Mona came back to us, smiling at Casey now.

"The hero!" She threw her arms around him and kissed his startled lips. "Father has told me how you found his brother."

He looked breathless when she let him go, shaking his head as if stunned with too much emotion.

"We heard a rumor on the last planet where we stopped," she said. "A tale too wild to believe, about three prehistoric clones who landed on a dead world and came back with a cure for the pandemic that had killed."

She paused to shake Pepe's hand and mine, and slip her arm around Casey, who gave her another silly grin.

"We didn't know you were the three. Or that it was Father's lost twin brother you found there, along with this new nanorob that had kept him alive. Father says it wiped out the killer pathogen and saved all our lives. A wonderful surprise!"

"But now—"

She shook her head, her fine skin

grown pale again.

"We never expected this. We've seen the jungle and the ruined memorial. Something else has hit the Earth. It can't be the same pathogen, because plants and animals are evidently immune, but we don't see any people. We can't hear any voices. Father's afraid the whole Earth is dead."

They huddled together again, Sandor's arms around Lo and Mona. We waited uneasily till Mona turned back to us.

"We must search for the killer, whatever it is. Father says the odds are better if we separate. He and Mother are going out to look at a space station we passed on the way in. It's still in geosynchronous orbit, but didn't respond to our signals. We sensed no life aboard it, but Father hopes it can tell us something."

"And you?" Casey peered at her, his dark faced tensed. "You?"

"I'm staying here on Earth. First of all, I want to look for Akyar."

"Akyar?" Casey frowned.

"I'm sorry." She gave him a smile of apology. "I forget to speak aloud."

"I'm sorry." Wryly, he grinned. "I can't read your mind."

"Akyar is—or was—a city in east Africa. Grown up around the Nexus building."

"The Nexus?" He squinted as if groping for her thoughts. "The government?"

"Not quite." She shook her head and went on soberly. "Planets hundreds of light-years apart could hardly be governed, but they did need contact. Trade was difficult, but they did need to exchange art and information, to unite their civilizations. If any shadow of coming disaster had been seen, the record of it should be there in Akyar."

She smiled at the anxious questions still lingering on his face.

"It was located in east Africa, under the satellite station. A symbolic position, really. It was on the equator near the edge of the Great Rift Valley. Near where

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Father says our evolution began."

"Please!" he begged her. "May I go with you?"

"I see no need." She frowned. "We don't know the killer. It's likely still active."

"Could be." Casey shrugged. "But whatever happened was long ago. Centuries, maybe, if you look at the ruins." His dark face set, he looked hard at her. "If you're in danger, I want to be with you."

She hesitated, frowning down across the ruins and turning at last to Sandor. Casey appealed to him, hands spread wide. I saw no sign from him, but after a moment she nodded to Casey.

"Father says you may be needed, as you were on the Sagittarian planet. Get your baggage."

We had very little baggage, only our space suits and a few gifts from the grateful emigrants. Casey rushed to get his bag from Sandor's pod and came back to wait by Mona's. She was lost once more in silent talk with her parents. At last she hugged them again, wiped at her eyes with the loose end of her sash, and beckoned Casey into her slider.

He waited a moment to let Pepe and me shake his hand, and jumped aboard. It lifted soundlessly, floated briefly over our heads, and slid out of space-time. Lo and Sandor stood gazing somberly down across the valley. A magnificent lion lay on a hill, looking down across a little herd of impala grazing toward the waterhole. Pepe was shaking his head.

"I'm sorry for Casey," he murmured to me. "He was always a dreamer, in love with an impossible dream. His only world is the cave in the Moon where we grew up. Mona may look like his vision, but she has lost her past. They'll always be strangers, from worlds too far apart." Moodily, he shrugged. "He's crazy to think they can ever get together."

He brightened when Sandor spoke to us.

"Do you want to come along to the satellite?"

"¡Seguro!" he whispered. "¡Seguro qué sí!"

He and I climbed into the pod to sit behind Sandor and Lo. The door flicked shut. The fallen log and the doorway in the cliff fell and vanished. With no motion I felt, we were again out in open space, the Sun so dazzling that we saw no stars.

Moving as the Earth turned, the station hung stationary over Akyar, which was too far for us to see. Suddenly only a mile or two ahead, it was a great silver wheel slowly rotating, blazing where the Sun struck it, vanishing into a shadow on the stars. Sandor and Lo sat frowning at it, listening, I suppose, for radio voices. I looked back at Earth, searching for Akyar.

"No visible damage." Sandor turned at last to us. "No minds we can sense. No hint of any life surviving." He paused to glance at Lo. "We're going inside."

The pod slid to a dome that covered the axis of the wheel. I felt a gentle impact, and we were motionless against it.

"We're suiting out," he told us. "The air inside may be harmless. It may be lethal."

They helped us seal our suits, and we went with them. The rear end of the pod was a small airlock that let us through, one by one. I found myself in silent darkness, afloat in free fall. Reaching around me for Pepe or Sandor or anything at all, I found nothing I could touch.

Cut off from light or sound, from all sensation, I felt helpless as a bug on a pin. A wave of utter panic struck me. I wanted to call out, to hear a human voice, but my trembling fingers failed to find the button for the helmet radio. I was all alone, drowning in the silence and darkness and death of the station, calling myself a fool and a coward . . . till lights came on.

At first they were only dim and unf-

miliar symbols, burning faintly through the blackness, but they let me breathe again. I found a shadow near me, Pepe's shoulder when I reached to touch it. Stronger lights rose to fill a vast empty cylinder. Glowing cords ran from us to points about the walls. We hung there for a time, seeing no motion, hearing no sound.

"Nothing," Sandor muttered. "No damage. No sign of accident or violence. Nothing to show what the killer was. Let's get out to the rim."

He caught a bright green cord that pulled him away. Lo and I followed. It brought us to a closed door in the cylinder's side wall. It opened when Sandor glanced at a green symbol. I followed into a tiny chamber that tipped and lurched to give us weight as it dropped toward the rim. It stopped, and we stepped out into an endless corridor that curved up ahead of us and behind, a circular tunnel that ran all the way around the rim.

"*¡La calle mayor!*" Pepe's spirits were higher than mine. "Main street."

It was the single street of a little city in space. Signs along it began to flicker and flash with dancing characters in an alphabet I had never seen. Sandor and Lo led us on. Centrifugal gravity was an odd experience. Though the pavement always rose ahead, we never had to climb. The great wheel of the station seemed to roll as we walked, pavement always level underfoot.

Sandor and Lo ventured very warily forward, pausing and pausing again to study everything, saying nothing of whatever they concluded. Pepe and I followed nervously. I didn't know what to expect. Battle debris? Dead bodies? Alien monsters?

We discovered no bodies, saw no life or motion. The pavement was bare and clean. We passed a dead machine that Sandor called a street sweeper. Dead, he said, because its power had failed. He stopped at a closed door. Symbols on it shone bright green when he looked at

them.

"The captain's office," Lo told us. "The door says he is in."

It slid open. We followed them into what might almost have been the reception room of an office on old Earth, furnished with seats along the walls and a wide desk facing us, all made of something that looked like painted metal or pale green plastic. The only color was a glitter of diamond beads on the rim of a long golden bowl on a little table. It must have held an ornamental plant. Dead earth filled it now, and dead leaves littered the table.

Lo and Sandor explored the room, shook their heads, opened an inside door. The room beyond held four empty chairs, behind four empty desks. I saw no books or papers I could recognize, no office machines or files, but a big black globe hung over each desk. One of them glowed when Lo looked into it. Peering past her, I looked into another office room, with another empty chair behind another empty desk.

Pepe reached to touch the globe, and his hand went through it.

"A holographic contact device," Lo told us. "Still connected to an office down in Akyar. Nobody there."

Sandor opened another door and stopped to stare. Pressing after him, we stopped and retreated. A dozen people had been seated around a long conference table, though not at any business meeting. The table was covered with dishes, empty cups and glasses, odd-shaped forks and spoons, gem-bright bottles, bowls filled with dusty fragments of what must have been food.

"*¡Una fiesta!*" Pepe murmured. "I think they died *muy contentos*."

"Whatever hit them," Sandor said, "it must have been sudden."

Men and women, they had belonged to his fine-boned and graceful race, but they were not handsome now. They had dried to mummies, the flesh brown and shriveled, black empty sockets in empty skulls staring blindly across the table at

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the other empty skulls. I felt grateful for my helmet. The odor must have been overwhelming.

"¡Los pobres!" Pepe crossed himself. "I hope they got to heaven."

3.

Mona called from Earth.

"She and Casey have reached Akyar," Sandor told us. "On the way, they flew north over the cities along the American coast and south again over Europe and the Mediterranean. Plants and animals seemed abundant, but the cities—" Lips set hard, he seemed to shrink into himself. "All tumbled into rubble and grown over with forest. They heard no radio, saw no open roads, no lights at night, nothing in motion."

Silent for a moment, he shrugged and went on.

"They've landed in an open park near the Crown. That's the Nexus building. There's life there, Mona says, monkeys in the trees and birds overhead. Most of the city fell into ruin long ago, but she says the Crown building appears to be intact, with no damage visible. They are leaving the pod. She wants to get inside if she can. They are out of touch till they get back to the radio in the pod. We'll wait here till she calls again."

We waited forever.

With Earth seeming stationary under us, time seemed to stop. We had no days or nights. Sandor and Lo spent endless times aboard the satellite, searching for clues they never seemed to find. Once I went back aboard with them, but all their talk was silent and I made nothing of anything I saw. I felt shut in, depressed by the strangeness and darkness of the station, the presence of too much death.

I preferred the stars, the illusion that we were floating free in open space, and Pepe's familiar company. Life in the pod was easy enough, so long as we could forget the dark riddles around us. There was food in the lockers, little

brown cubes that water expanded into something I learned to eat. The seats reclined when we wanted to sleep.

Empty time on our hands, we watched the Moon's deliberate creep around the Earth, the sun's slow creep across the face. Though Tycho and the station were too far to see, I found myself grieving for Tanya and the others we had left there, alive and well when we left them but surely dead centuries ago. Or had they been all been cloned again, and us with them, when the computer saw that Earth was dead?

We watched the monsoon clear over Africa and waited for whatever Lo and Sandor might discover. Though they seldom slept, they came back to the pod now and then to eat and rest and try again to reach Mona. She never answered. Pepe urged Sandor to follow them to Akyar, to help if they were in trouble.

"They expected trouble." Frowning, Sandor shook his head. "That's why we separated. To double our chances. And we still have work to do here. We're confirming a date for the disaster. Whatever happened, it was a bit over two hundred forty Earth years ago.

"It certainly was not the Sagittarian pathogen, which was carried by interstellar travel and killed all organic life. We've read the records in the operations section here. Interstellar craft and Earth shuttles were still arriving and departing in a very normal way till that last moment."

His elfish face twisted as if with pain.

"We entered the room of an operations clerk who had just returned from a vacation on Earth. She had bought gifts for her friends. A neat little model of the prehistoric rocket craft from Tycho Station. A toy elephant still able to spread its ears, trumpet, and charge across a table top. Holo cubes of life in motion around the restored Taj Mahal and the Parthenon. All still wrapped and labeled with names, but never delivered."

With no time of our own, we counted days by the sunlight that marched and marched again over motionless Africa beneath us. Thirteen had passed before Sandor got a call from Earth.

"They're safe." His thin-chinned face had lit. "Back in their own pod. Ready to tell us what kept them so long."

Gliding down to Africa, we found Kilimanjaro grown taller since the great impact, a new caldera at the summit filled with snow. A chain of narrow lakes now filled the long valley of the Great Rift, stretched deeper as the continent was torn apart. Akyar stood east of the Rift, on the high plain that sloped toward the Indian Ocean. Seen from the air, the city made a target pattern, a bull's eye surrounded by circular streets cut into blocks by wide radiant boulevards.

"Akyar." Sandor gestured at the bull's eye as we slid past it. "That's the Nexus building at the center. Called the Crown for its shape."

It was magnificent. White columns that looked tall as the Washington Monument supported a vast golden dome topped with a needle spire that flashed with lances of rainbow color like a single enormous diamond. Gigantic animal figures marched around the base of the dome. A tyrannosaur, a mammoth, a saber-tooth tiger. Ahead of them a horse and a camel, a lion and a llama, a gorilla and a man.

"The lords of the universe!" From Pepe, a bitterly ironic laugh.

"At least the center of civilization." Peering down at the spire's prismatic splendor, Sandor shook his sleek-furred head. "That's our riddle. In a world that that spanned so many planets, so free from trouble or any hint of trouble, what could go so terribly wrong?"

"I hope Mona has the answer."

He took us low over the diamond needle and turned in his seat to point at the silver gleam of Mona's slider pod, landed in a little park beside a broad avenue

that ran west from the Crown. We landed near it. Looking around us through the transparent hull, we saw nothing of her or Casey, but Sandor opened the door. We tumbled out.

I heard a high-pitched bark. The grass around us was scattered with ring-shaped mounds of bare brown earth. A small brown animal stood upright on the nearest mound, barked again, and vanished down a hole in the middle of it.

"A cunning little creature," Lo murmured. "Mona would love it."

"A prairie dog," Pepe said. "My father used to see their towns in Texas when he was a kid. Dr. DeFort was trying to preserve what he called biodiversity. He tried to save tissue specimens from all the creatures—"

"¡Amigos!" Casey's shout stopped him. "¿Qué pasa?"

He and Mona were climbing out of their pod. They amazed me. Holding hands, they wore bright green loin-cloths and garlands of huge scarlet flowers, and nothing else. His broad black face shone with a happiness I had never seen on it, though he turned a little sheepish when she dropped his hand and ran to hug Lo and Sandor.

"Pep, Dunk, I'm glad you got here."

He shook our hands and looked back at Mona. She stood with her arms around Lo and Sandor. They were laughing, absorbed with one another. He stood a long moment watching them before he turned back to us.

"I never expected—" He checked his eager voice as if abashed by his own emotion. "Never expected this."

Near us was a very solid table, made of what looked like green-veined jade, with seats on either side. He gestured for us to sit. Still heavy under Earth gravity, Pepe and I were glad to comply. After another fond glance at Mona, Casey joined us. We asked what they had found.

"Not a clue. Nothing I could understand."

Seeming untroubled by that failure, or even the death of Earth, he let his gaze drift back to Mona. She waved, with a smile that seemed to enchant him, and escorted Lo and Sandor into her pod. Casey sat staring dreamily after them till Pepe touched his arm.

"Sorry." He blinked as if he had forgotten us. "I was thinking."

"We got inside the satellite," Pepe told him, though he hardly seemed to care. "All we found was dried-up bodies, with nothing to show what killed them." He gestured at the towering Crown. "You've been in there?"

Casey's answer was only a nod.

"Tell us about it."

"It's too big." Yet he shrugged as if its vastness hardly mattered. "We didn't see a tenth of it. Or anything I understood."

"Nobody alive?"

"Nothing." At last he gave his attention back to us. "Though there is a staff of robot caretakers and janitors still active. If people died there, their bodies must have been removed."

We sat there, craning up at the diamond spire and the animals marching around the great golden dome till Pepe pressed him to tell us more.

"It was really something wonderful." Awe slowed his voice. "It had a computer system linked to all the nanorobs everywhere. That made it a sort of super-mind, Mona says, in contact with similar centers on all the settled worlds. The mind of all humankind."

"Is it still alive?" Pepe asked. "Does it know what hit the people?"

Casey shook his head. "The robots do keep the computer running. All the old data is still there, but Mona says nothing has been added since the blackout."

Another prairie dog had popped up to bark at us again.

"I'm glad something is alive." He grinned as if it cheered him. "No matter what struck us, evolution can happen again."

Pepe asked if they were going back to

the building.

"No use." The grin gone, Casey shook his head. "Too much death! It wore on my nerves. I was glad to get out."

"Won't Sandor want to see it?"

"There's plenty to see." He seemed to shrink from its towering mass. "Half of it is underground, level after level. Mazes of corridors go on and on forever. We got lost once, and had to find a robot to show us back to anything we recognized. The robots follow orders, but they never tell you anything. You won't see them outside, though they do keep up the building."

He paused, something like dread in his eyes.

"It's too much! Too much of everything. Embassies from all the settled planets, with holo exhibits to tell all about them, all tied in to the main computer. Libraries, museums, laboratories, businesses, tourist and information offices, art galleries, theaters, facilities for sports I never heard of. Even a sort of luxury hotel, with a robot staff ready to put us up."

Grinning again, he touched his floral necklace as if in apology for it.

"And Mona!" He intoned the name almost with worship, and leaned very earnestly toward us. "You know I've dreamed we'd somehow be together ever since I first saw the holos of her and El Chino, but I thought it would never happen."

He drew a long breath.

"But it did." His dark face shone. "You've seen her. She loves me. We've been together in paradise!"

Mona had stepped out of the other pod, carrying a basket. He darted to take it from her and set it on the table. She opened it to spread a cloth and begin laying out dishes and glasses, bowls of food, a flagon of amber wine.

"The robots packed it for us," Casey said. "They do remember what they were."

Lo and Sandor came to join us at the

table. Mona was pouring the wine. Casey handed out round golden fruits.

"They're nothing we ever had on the Moon. I don't know a name for them, but just try them."

"Peaches." Sandor bit into one. "From cell specimens I found at the lunar dig. I had them in my orchard at the memorial."

Mona split another and shared it with Casey. Mine was delightful. There were cups of soup, cakes, nuts, jellies. Some I didn't like at first, but the amber wine enhanced the flavors till I relished everything. Lo and Sandor glanced at each other when we had finished, and stepped away from the table.

"Excuse us, please. We have things to think about."

Mona caught Casey's hand and led him after them. The four stood a moment gazing up at the dome, then put their heads together, lost in silent talk. There was enough, I thought, for them to think about.

"*¡Dos locos!*" Pepe shook his head at Casey, a shadow on his face. "I was wrong to think they'd never get together. They've gone crazy for each other, and forgotten the world is dead."

4.

The four stood together in silent contact, until Lo and Sandor abruptly broke away and walked quickly toward Sandor's slider pod. Without a word, Mona dropped Casey's hand and followed them. He stood frozen, staring after her with something close to terror on his face.

"Mona?" A breathless, voiceless whisper. "Why?"

"There's no time." She darted back to touch his gaping lips with a kiss. "No time at all."

She slipped away before he could embrace her, and ran after Lo and Sandor into the pod. The door snapped shut behind her. He turned to look at us, empty hands spread in mute appeal. I felt his shock and knew no way to help him.

"*¡Demonios!*" Pepe muttered. "*¡Fantasmas de los muertos!*"

Ghosts of the dead.

Darkness was thickening around us, the prairie dogs fallen silent. The spire on the Crown glowed softly, lighting the dome and throwing long black shadows across the trees and rubble mounds around us. Far off in the forest, I heard a strange, quavering scream. Only some night thing, I thought, calling for a mate, yet I felt the hair bristle on the back of my neck.

The pod simply sat there.

"Why?" Casey stood staring at it, stricken and dumbfounded. "Why did she leave me?"

"*Dios sabe.*" Pepe shuddered. "God knows. Or has Satan claimed the world?"

We stood there a long time, shivering in the night wind, waiting for them to come out of the pod, for it to lift, for anything. The pod lay silent and motionless, a mirror-shelled mystery, gleaming faintly in the glow of the spire. Casey shouted at it once, begging hoarsely for Mona to open the door. It didn't open. He didn't try again.

Tired of standing, Pepe and I went back to the table. A handful of biscuits were left in Mona's basket, along with a little wine in the flagon. Sitting there hunched against the wind, we called Casey to join us. He stood deaf to us, fists clenched, shaking his head at the slider, while we finished the biscuits and wine.

The door of the other pod was still open. To escape the wind, we crept inside. I reclined a seat and lay there a long time, staring out through the glass-clear hull at Casey and the motionless pod, watching the slow Moon climb past the shining spire. Pepe kept muttering Spanish profanities in his uneasy dreams. Thanks to the wine, at last I slept.

Casey was inside with us when I woke. He lay snoring on the floor, hollow-eyed and haggard, black bristle on

his chin. The prairie dogs greeted me with a chorus of barks when I climbed outside. Sandor's pod still lay where it had been, a mirror-bright enigma under the morning sun. Pepe rummaged through a locker and found hard dry slabs of something that tasted like burnt oatmeal. We ate a little of that. Casey went out to listen at the other pod, his ear against the mirror hull, and came back dismally silent.

"¿Qué importa?" Pepe frowned at it. "We can't wait here forever."

"I dreamed." Casey was moodily grim. "I dreamed they were dead."

"If they are." Pepe shuddered and crossed himself. "We ought to see."

He walked away toward the street and came back with a heavy chunk of broken pavement and lifted it with both hands to smash at the side of the pod.

"Don't!" Casey called to stop him. "There was more of the dream. I was trying to get inside. I heard Mona calling words I remember. 'Gold eight, red six, black four, white two.' The door came open. That's when I saw they were dead."

Pepe dropped his rock and bent closer, staring at the side of the pod.

"¡Mira!" he whispered. "¡La cerradura!"

He had found four colored dots on the mirror shell. Gold, red, black, and white. He tapped them carefully one by one, counting the taps aloud. The door yawned suddenly wide. We followed him inside.

They lay in the seats, lying flat and still. Mona's eyes were open, glazed and blindly staring, her beauty distorted into a frozen grimace. Her arm was cold and hard when I touched it, set in rigor mortis. Casey dropped to his knees beside her. We went out and left him there.

"¡Cabrón!" Pepe muttered. "¡Madre de Dios! How can God allow such things?"

Or was there any God at all? What sort of power would murder innocent and

unsuspecting planets without warning or cause? I knew no answer.

Casey staggered out of the pod at last. He looked pale and shattered, as if life had bled out of him, yet he was fighting to recover himself, his hollowed eyes dry, his jaw set hard.

"What killed them?" Pepe asked.

He shrugged and shook his head.

"I think Mona knew, when she came back to kiss me good-bye. I think she wanted to tell me, but it gave her no time to say."

He wanted to bury the bodies. The soil was too hard, Pepe said, for us to dig the graves with any tools we had. The pod, he thought, should be tomb enough, but the dried-up mummies we found on the satellite still haunted Casey.

"We'll burn them," he said. "We'll build a funeral pyre."

We had no axe to cut timber for it, but storms had shattered old trees along the neglected streets. We spent most of the day lugging and dragging and piling fallen limbs, the annoyed prairie dogs scolding at us. When Casey declared we had enough, we brought the bodies out with as much respect as we could and laid them side by side on the pile.

We discovered then that we had no way to ignite it. Pepe wanted to search for flint and steel, but Casey recalled a science exhibit he and Mona had seen in the Crown. He went back there and returned with a concave mirror. A dead leaf under it smoked and burst into flame. Pepe bent his head and murmured a Spanish prayer. We threw more wood into the blaze till sunset.

Next morning the ashes were dead. We gathered the flakes of bone into Mona's basket. When I wondered what to do with them, Pepe offered to scatter them out of the pod. That astonished me, because Sandor had seemed to fly with magic, never touching any controls. No magic, Pepe said; his nanorobs had done it with their magnetic and electrostatic fields. Sandor had taught

him how to use the control stick.

"The Serengeti." Casey nodded gratefully. "I saw a herd of wildebeest there. Mona loved animals."

Pepe flew us high over the ice-filled crater at the top of Kilimanjaro's enormous new cone and back down to skim the eastern shore of a wider Lake Victoria. Gliding low over the lush green grasslands of the Serengeti, we opened the door. Wildebeest, gazelle and zebra fled ahead of us, and wide-winged birds scattered from a waterhole. Casey stood in the open door, scattering the ashes.

"Immortals." Pepe shook his head sadly as he closed the door and stopped the roaring wind. "I wish they had been."

He brought us back into the long shadow of the Crown and landed again among the scolding prairie dogs. Still in his seat, he looked around at Casey and me.

"¿Y ahora qué? What next?"

Casey shrugged. I felt crushed under black despair. We three were here alone with the animals now, without friends or food or the instincts that kept them alive. Groping for any purpose to stay alive, I asked Pepe if he could take us back to the Moon.

"The computer will surely be cloning us again," I told him, "when it knows the Earth is dead. Whenever that happens, our new brother ought to have our account of what we have seen."

"The station wouldn't let us in." He shook his head. "Sandor left it sealed."

Still, I felt desperate to escape all the riddles of ruin and death that hung over us. Could he fly us to Lo's home planet? Or maybe on a flight that would take another thousand years? I thought we might hope to find ourselves cloned again when we get back, and Earth restored to life.

He brightened for a moment, but shook his head again.

"I'm not an interplanetary pilot. Even if I were, we might not find any world alive. Or anybody who thought we

might carry contamination would shoot us out of the sky."

He landed us again among the startled prairie dogs. By sunset we were out of the pod, sitting again at the jade table, making another meal out of the hard biscuits Pepe had found in the locker and wondering how to stay alive.

"We can live in the pod, but this—" He stopped to scowl at a bitten biscuit. "Even this pig feed won't last us long."

We talked of trying to farm or hunt, but we had no seed or tools to turn the soil, no weapons to kill the game around us, not even the prairie dogs, no know-how for anything. Casey kept moodily silent, gazing up at the spire above the Crown, till Pepe asked if he knew any way for us to stay alive.

"We carry the Sagittarian nanorobs." I heard his bitter irony. "They ought to make us immortal."

"So did Sandor," Pepe said. "They didn't save him."

"We don't know what they are." He nodded, looking up at the Crown, its golden dome, a huge half moon rising into the dusk. When he spoke again, it was more to himself than to us. "Mona thought she had picked up those nanorobs from me. She was searching to understand them, hoping they would shield us from whatever killed the planet. I think she was finally in sight of something that had begun to terrify her."

Lips compressed, he shook his head.

"What she was finding, or thought she was, I never knew. She'd learned to read my mind, but hers was blank to me. We were in love, and she seemed happier and more hopeful toward the end. I was happy with her."

With a long sigh, he shook his head and sat a long time remembering.

"We hoped to live forever," he went at last, his tone wistfully forlorn. "We used to laugh and talk about the good times of our lives. She wanted to know what her life might have been if Sandor had let her grow up with us on the Moon.

ANALOG

She was fascinated with the story of the great impact and the history of the station. She talked about her travels with her mother, and all the odd creatures she had seen. She loved every new species, every sort of life. And the Crown—”

A momentary smile lit his face.

“While it lasted, we had a great life there. She enjoyed everything the robots gave us to eat and drink. We had wonderful nights in bed. She was always searching. Happy, toward the end, with whatever she thought she was finding.”

He looked up at the spire, a new determination of purpose in his eyes.

“I’m going back inside.”

Next morning he did. Pepe and I followed him out of the pod to a broad avenue that once had been magnificent. Great trees had stood along it, most of them dead or dying now. A tall tangle of vines and brush walled the crumbling pavement. We had to scramble around fallen logs and clamber through a rocky gully that floods had cut.

Towering at the end of the avenue, the building was farther away than it had looked, even more colossal. We took most of an hour to reach the jungle-clotted gardens around it. Weeds and brambles filled a long crescent pool below the entrance. A gigantic golden figure towered out of it, one great arm lifted to hurl a wheel-shaped ship into space.

We stopped again and again to gaze in awe at the topless columns, the great animals marching around the dome, the fire in the diamond spire. Their immense dimensions and the sense of death and long decay hit me with a sudden ache of longing for our safe little digs in the Moon, but Casey plunged doggedly on.

We followed him around the end of the crescent pool and up a ramp of something like white marble to a monumental doorway. The door was an enormous golden slab, deeply engraved with

another gigantic figure, this one lifting a planetary globe toward the sky.

The globe held me hypnotized.

An island of life on this ocean of death, it glowed with vivid color. Spinning, it glowed with cloudless blue seas and green continents patterned with what I thought must be roads and cities, sometimes a flash of polar ice. It changed as it turned. The hemispheres that vanished never came back. With every rotation, it revealed another world.

I stood gawking at it till a narrow panel opened at the bottom of the door. A bone-white robot stepped out to meet us, a human-shaped figure so graceful in form and motion that for an instant I took it to be alive. It stopped to block the entrance, stood still for a moment to inspect us, raised a silent arm to beckon us away.

Pepe and I backed off uneasily, but Casey stood his ground, calling out something that echoed the intonations of Sandor’s speech. The robot stood frozen for half a minute, then glided aside and beckoned us to enter.

5.

Emptiness met us. Emptiness, darkness, silence. Yet the great building still had a life of its own. Light brightened around us. Another bone-white robot came noiselessly toward us across a vast, vacant floor. It stopped when Casey uttered some command he must have learned from Mona, and we stood peering around us.

We had come into a lofty hallway that curved around the building’s outer wall. Holo murals were lighting along it, panel after panel. Windows into worlds beyond the Earth, they showed alien landscapes and monumental buildings, spaceports and spacecraft, strange plants and stranger animals, figures and faces of human beings that sometimes looked nearly as strange.

Casey gestured at them.

“The colonized planets. They all had

people here. Delegations, traders, tourists, what have you. The Nexus united interstellar civilizations. Centers like this held them together."

Pepe stood frowning at a rugged landscape as red and lifeless as Mars. A huge blue balloon rolled across it on a wide roadway that led into dusty distance. Three smaller blue globes bounced along behind it.

"It looks alive," Pepe said.

"It was." Casey made a stoic shrug. "But Mona found no evidence of any contact later than two hundred forty years ago. She was afraid that meant the whole human enterprise was over. But yet—" He frowned and shook his head. "Toward the end, she did seem happier. I don't know why."

The robot had stood waiting. Casey spoke to it now. Its answer echoed the accents we had first heard from Sandor when we were children on the Moon. He nodded as if he understood, and it beckoned us along the endless curve of that hushed and empty hall. Wide archways were spaced along its inner wall, signs above them glowing with symbols as strange as cuneiforms. Pepe held back, hesitant to follow the robot.

"They know us," Casey assured him. "Mona introduced me."

It turned to lead us through a tall arch, into darkness. We had to wait for lights to come on to fill another great hall, which ran toward the center of the building. Far along it, a robot was pushing some silent device that must have been sweeping the floor. I heard no sound, saw nothing alive.

"There really were people here?" Pepe asked uneasily. "Not just machines?"

"Thousands," Casey said. "Many thousands. From nearly two thousand planets."

"If they died here—" Staring down the empty corridor, he must have recalled the shriveled mummies we found on the satellite. "What happened to

them?"

Casey grinned at his unease and nodded at the robot.

"The robotic caretaker staff removed them."

The robot led us through a door into an elevator that surged silently upward.

"I want you to see the Earth section, and the sector from Lo's planet, where Mona grew up. Just a tiny fraction of the Crown, but as likely as any, she thought, to tell us why they died."

We spent a long day trudging along empty corridors and through empty halls, trying to understand anything we saw. These centers were built, Casey told us, to unify the cultures and share the arts and sciences of all the scattered planets. Such interests as tourism and trade had supported them.

"You have to admire the interstellar trader." I caught a note of envy in his voice. "He had to swallow the risks of packing up his goods and flying off to some far star, knowing he would never get back to anything he knew. What a great adventure, if he could make friends and find a market for his cargo. Without such luck—"

He shrugged.

Casey was our guide through the Crown. He could give the robots simple commands and understand simple replies. I caught a sense of the eager purpose that drove him, but understood nothing of what he tried to show us. We walked through laboratories devoted to sciences I'd never heard of, museums filled with artifacts that were hopeless riddles, libraries filled with information in a hundred tongues I didn't know.

We looked into splendid theaters without players, great lecture halls without speakers, enormous stadiums where many thousand empty seats looked down on bare arenas. There were endless galleries of art that left only cold confusion in my mind, great empty music halls that greeted us with cacophany

nies of shrieks and thunder, shops filled with tantalizing enigmas. We walked through universities where we might have mastered all the arts and crafts and sciences of all the worlds, if our nanorobs had been tuned to teach us. We took holo tours of worlds where evolution had created what looked like nightmare madness, and worlds that had known no life at all before the survey teams set down.

We found no promise of anything left alive.

"*¡Fantasmas!*" Pepe shivered.

Ghosts. We glimpsed no actual apparitions, but the silence and the emptiness had begun to people my own imagination with the phantoms of all the thousands who had lived and worked here, died and disappeared. Footsore and exhausted, I felt relieved when Casey finally said he had showed us enough.

Next day we let Casey go back alone.

The robots admitted us to spacious apartments that took my breath. The magnificent lobby was walled with vivid holos of the long Terran history since our last clones came down from the Moon. A forest of live floral plants perfumed the air in the great dining room. Our private chambers must have been intended for celebrity guests.

Always waiting alertly to serve us, the white robots opened a pool where they taught us to swim, a gym where they massaged us, a game room where they waited to watch us play. They were expert chefs, ready to obey any orders we could make them understand. Under Pepe's coaching, they were finally able to serve him a fair copy of the *buevos rancheros* his father used to make on the Moon.

I don't know how long we were there. Never outside, we never saw the Sun. Pepe's gift timepiece had settings for many hundred planets, but he had lost the one for Earth. Casey became our clock. His days were long, spent wan-

dering through the labyrinths around us in search of any thread of meaning he could recognize.

"I'm learning," he insisted. "I think my nanorobs are beginning to kick in. 'Sometimes I understand something in a holo lecture or find an inscription I think I've read correctly.'"

"But what's the use?" Pepe asked him. "If nobody foresaw the extinction, what could they have left to tell us anything about it?"

"Mona had a theory." We were still at the breakfast table. Frowning, he pushed back an unfinished dish of some odd-odored brown stuff he said he had come to like. "A notion she got out of ancient history. The story of a revolt against the nanorobs, back when they were new. The rebels felt that they were stealing human freedom, turning us into machines."

Pepe was nodding. Looking across the table into the unwinking lenses of the robot standing behind his chair, I couldn't help a shudder. Its silent stare reminded me of the microscopic robots flowing in my own blood and multiplying in my brain. I lived in terror of them.

Sandor said they had saved our lives on the Sagittarian planet. Certainly they gave me no aches or pains. Perhaps they had made me immortal. Perhaps they would kill me tomorrow. I shrank from that haunting uncertainty, afraid they might steal my mind.

Grinning when I shivered, Casey continued.

"The conflict became a sort of religious war. Most of the rebels died. The survivors seized spacecraft and fled to settle new worlds on the star frontier. Mona was searching exploration records, looking for any evidence that some of them might be still alive, somehow striking back."

Pepe shrank back from the robot clearing the table.

"Striking? How?"

"That's what she wanted to know." Casey shrugged. "Perhaps in some way

through the nanorobs themselves. Perhaps something that killed their carriers when it killed them. She was searching the reports of later explorers. Surveying every planetary system within ten thousand light-years, they found several planets where the rebels had landed, but none of them alive. Without nanorobs of their own, they failed to adapt to new environments. Their efforts at terraforming efforts had failed. She found no proof of anything, yet she never gave up looking."

"Whatever it was that killed them and everybody else," Pepe muttered, "I don't think I want to know."

One morning Casey came in late for breakfast. Still in the silklike blue-striped night wear the robots provided, he hadn't let them shave him. He ate nothing, but took coffee when the robots offered it, a better brew than we had ever tasted on the Moon. When they had cleared the table, he spoke abruptly.

"I dreamed last night." He pushed his empty cup away, and paused to scowl in bafflement. "A dream I can't explain or understand. It seemed too real to be just a dream, yet too strange to believe. I thought—it's hard to explain, but I thought I had a sort of infinite vision. I could see everything that ever happened."

He squinted to see if we suspected his sanity.

"I saw Mona's clone mother, Mona Lisa Live, back when she really was alive." He sat staring past us, as if searching some remote infinity. "She was a singer in a Medellin hot spot. My clone father was there as a hired guard for a drug lord called El Matador. Maybe high on his own merchandise, Matador tried to rape her. When he wouldn't lay off, my father shot him down."

"Matador had gunmen all around him, but my father got away with Mona in Matador's armored car. Got off the ground in Matador's private jet. Skirted the Pacific coast from Colombia to Baja.

Found friends there. In the dream I was with them all way, though they never knew it."

His dark face quivered with emotion.

"I was proud of my father. He had cunning. He had guts. The Matador cartel had men waiting in Baja, hired to kill him, but he beat them. Escaped with Mona to *el Norte*. Got another job as a guard at DeFort's White Sands Moon base. With the asteroid coming in, he got Mona on the escape plane. Got her to the Moon. Got DeFort to let them stay, and save their cells in the cryostat. They were very much in love. I've always longed to live a life with her the way he did."

"But now—"

He sat in silence till Pepe said, "I'm sorry for you, Case."

"I know she's dead." His voice had fallen low. He gazed away again, till I saw a dazed smile breaking over his face. "Or maybe she isn't. The dream went on." He looked back at us, his eyes lit with wonder. "You remember those blue balloons rolling across the desert? I was there with the explorers who got the holos, and I got closer than they ever did."

"I could touch the minds of the balloon beings, though they never felt me. One of the babies was lost from its mother, frightened and bouncing across those dunes trying to find her. She was searching for it, but rolling in the wrong direction. I wanted to tell her, but I couldn't."

"That was the strangest thing in the dream. I could feel the baby's terror and the mother's fear. I could understand their cries. I tried to guide them toward each other, but they were deaf and blind to me. Thinking about it since I woke, I think I understand. It was all happening in the past, light-years away from Earth. I think the past is fixed. I could somehow sense it, but never change a thing."

"Happening, you say?" Pepe's eyebrows had risen. "Really?"

"I'd like to know." Casey shook his

head, staring off at nothing. "I can't expect you to believe—but it did seem terribly real. And there was still more."

Abruptly, he stood up from the table.

"Before I woke up, Mona was with me. The clone Mona, born with us back at the station. The Mona called Tling when we found her at Sandor's memorial. The Mona we burned on the woodpile. Alive again!" An eager smile wiped the pain from his face. "She was calling me from somewhere out in space. She's real! I don't know how or where, but I want to find her."

6.

Casey drained another cup of coffee, went back to his room, and returned in the work togs the robots had provided, a snug-fitting jumpsuit cut of some sleek, bright-orange stuff. We were still at the breakfast table.

"You think I'm crazy?" He grinned when Pepe looked up at him. "Could be, but I'm going to look for Mona."

Pepe asked where.

"Where else?" He shrugged. "Toward the end, she thought she was on the trail to something more than those anti-nanorob rebels. She never said what it was. She was frightened at first, trying to deny it and afraid to say. Toward the end, it seemed to make her hopeful."

"Casey, please." Pepe raised an anxious hand. "I'm not calling you crazy, but we've all been through hell. Let's take a break and look at the odds."

"If we knew the odds—"

"We know enough. The Crown's too big. A great haystack. You'll be looking for a needle you wouldn't know when you found it. I doubt it's there at all. Better eat your breakfast. Let the robots rub you down. Sleep tonight. Wait for Mona to come back in another dream, with maybe more to say."

"Thank you, Pep." Casey came around the table to shake his hand. "It's true I don't know what I'm looking for, but I can't stop now. Maybe Mona was wrong to fear the nanorobs. Maybe they

can help us. We carry those we picked on the Sagittarian planet. I think mine are still working their way into my system."

"Huh?" Pepe blinked in alarm. "Doing what?"

"I think they're getting into my brain."

"Driving you mad?"

"If I am." He shrugged. "But they've begun to teach me facts I never learned. Mona was speaking Sandor's language in the dream, but still I understood her. I hope she'll help me find her now."

When he moved to leave, Pepe asked if we could come with him.

"Okay." He shrugged, with an ironic grin. "If you think I need looking after."

"I do." Pepe nodded soberly. "If your nanorobs are waking up, I'm afraid they'll kill you."

He waited for us to dress. We followed him though the jungle-grown rubble back to the Crown. The robots let us in. We tramped after him all day, through endless corridors that lit as we entered, and countless empty rooms that depressed me with the hush of death. Now and again he stopped to watch a blank holo wall come to life, to question a robot for an answer I never understood, or to stand waiting as if expecting inspiration that never seemed to come.

Yet he blundered on, finally through a bewildering maze of offices that he said had been the administrative complex. We came out at last on a balcony that looked into a pit of darkness. I shrank back from a railing that seemed too low. Pepe caught his breath and shouted, his voice a little quavery.

"*Viva! Viva! Viva!*"

We stood waiting a long time in silence before the faint echo whispered back. His voice woke stars overhead. Faint at first, they blazed into constellations brighter than any we had seen in space. They revealed an enormous hollow space at the center of the building.

The immense curve of its wall was

lined with balconies like ours, rising level after level toward the dome; and falling level after level below us, so far that I caught a giddy grip on the railing. Peering down, I found a circular floor, vast and bare, ringed with row upon row of desks on a slope that rose to the wall.

"*¡Qué grande!*" Pepe murmured in awe. "The council of the stars! Imagine the leaders of two thousand worlds gathered here, with all their science and wisdom, debating the future of the Universe!"

"Wisdom?" Casey grunted. "They never knew they were about to die."

He shrugged and led us off the balcony, back into the labyrinth. Grimly determined, he watched holos that spoke in silence if they spoke at all, queried robots for replies that were only noise to me, paused again and again to listen for a voice he never seemed to hear. Worn out, we stopped at last to say we'd had enough.

"We're going home for supper," Pepe told him. "If we can call it home. Better come with us."

Stubbornly, he shook his head.

We ate a meal I hardly tasted, our robot servers standing behind us, Casey's empty chair across the table. The holo wall shone with scenes I hardly saw, landscapes on other worlds, far away and long ago. I was asleep before Casey came in. At breakfast his chair was empty again.

"He was here," Pepe said. "I heard him speaking to the robots, but now I just looked in his room. He isn't there."

Longing for distraction from problems too big for us to solve, we turned back to the holo wall. A strange seascape had filled it: yellow surf foaming on the shore of an endless yellow ocean under a lurid yellow sky. Huge ungainly creatures the color of blood came crawling out of the foam and up a broad beach of orange sand.

"Huh?"

I heard Pepe gasp. The wall flickered. The beach and the creatures were gone. Instead, I saw the world around us and Casey running desperately through the prairie-dog mounds. His eyes on Lo's slider pod, he failed to see a dirt-rimmed hole. His foot went in it. He fell on his face, staggered to his feet, limped on till his injured leg collapsed. On all fours, he scrambled on to the pod. The door sprang open. He tumbled in. The door snapped shut. It darted away.

"*¡Caramba!*" Pepe muttered. "*¡Pobre hombre loco!*"

The sky in the holo turned yellow again. The prairie dogs were gone. Once more the great lizard-things came crawling through the surf. Dragging long crimson tail-fins, they were stumbling clumsily to stand on wide-webbed rear feet. One by one, they bowed their long-jawed heads toward a huge black globe, waddled into a circle, and shuffled slowly around it.

We sat there a long time, cringing from a dread we didn't want to face, watching what seemed to be a ceremony of worship. The robot brought Pepe a stack of something like *tortillas* he had taught them to make, with a bowl of something like *frijoles* seasoned with something like *chili*. He waved the robot away.

"They're probably still alive. The explorers never settled worlds with any kind of intelligent life, and the creatures had no nanorobs to kill them. If nanorobs can be killers. No matter what becomes of us, evolution still has a chance."

He had the robots erase that yellow sky to let us see the rubble and jungle around us and Kilimanjaro towering in the south, cumulus piling up around lower slopes below the snow-crowned double cone. A small brown prairie dog stood guard on a mound where Casey's pod had been.

We left the table at last, to search his room for a farewell note or any hint of

what had changed him. We found nothing at all. Pepe tried to question the robots. They kept repeating that they were ready to serve us, but they had been programmed for nothing more.

I told Pepe that I was going outside.

"Why?" He gave a narrow glance, as if to appraise my sanity. "Casey's gone. God knows where."

But I had to get out of the Crown. It was too big, too empty, haunted with too many riddles, too much death. Pepe must have felt the same way; he came out with me down the ruined avenue, back to the prairie dogs. They barked a greeting and scurried into their dens. We sat down at the jade table, and Pepe kept glancing at the empty pod where Sandor and Lo and Mona had died.

"I could fly it." He sighed and shook his head. "But where could we go?"

We looked for alternatives. With the station asleep, we couldn't go back. He was not qualified for interstellar flight. Could we get away to some nearer planet? Maybe Mars?

"Dead as Earth." Pepe shook his head. "Sandor told us about an early project to terraform it by steering ice asteroids into collision orbits. That was given up when the interstellar sliders opened better worlds. We're stuck here with the robots, so long as they tolerate us."

With nothing else worth doing, we sat there watching the prairie dogs spy on us from their pits, stand upright to bark at us, scurry again about their business. Noon passed. I was feeling a pinch of hunger, hating to go back into the tomblike Crown. A concussion sent the little animals darting back to their dens. A sound like near thunder boomed out of the western sky.

"Casey." Pepe made a dismal face. "*Pobrecito*."

We found him a mile or so down an avenue that ran toward Kilimanjaro. The impact had dug a deep pit beside the pavement. In the bottom of it we found twisted fragments of the pod, and red

stains of Casey's blood.

"The Sagittarian nanorobs." Standing on the crater rim, Pepe stared at me and shook his head. "He said they were getting into his brain. I guess they did."

We went back to the Crown, brought shovels from an exhibit on the history of mining, and spent a long afternoon shoveling dirt back into the crater, finally covering the mound with rocks from the debris. I wanted to find something to mark the grave. Pepe shrugged.

"Who's left to read it?"

The robot guards let us back into the Crown. Our robot servers set out a meal we barely tasted. The holo wall was alive again, showing a tourist train crawling around Sandor's memorial as it had been when it was new, chuffing past the Washington Monument. The crouching Sphinx stared across the mall at the Acropolis and the Great Pyramid. I found the gleam of our replicated station dome on the replicated Tycho rim, and felt a pang of longing for its familiar tunnels and all we had lost.

Pepe shook his head at a robot who was offering glasses of a bright-red wine.

"I guess we're to spend what's left of our lives here." Gloomily, he shrugged. "So long as they want to look after us."

I was half asleep and aching from our labor with the spades, but I didn't want to be alone. Neither did Pepe. When the robots offered wine again, he let me persuade him to take another glass. We sat there half the night, sipping glass after glass, sometimes teary with grief and nostalgia, watching holos of Sandor's excavations at the lunar site and the whole human story as he had pieced it back together from what he uncovered there.

"Maybe just the way it happened. Maybe not." Pepe shrugged. "*¿Qué importa?* Who's alive to tell the difference?"

We saw ape-men leaping out of the forest to grassy savanna, learning to walk upright and carry food or weapons in their hands. We saw a naked woman running from a river of red-hot lava,

loose hair flying, a smoking stick in her hand, saw her kneeling to pile dry leaves and twigs on the stick and blow on them till she had a fire. We saw shaggy men working in caves by the light of smoky torches, painting the animals they hunted on the limestone walls. We saw men with sharpened reeds pressing marks into soft clay tablets. We saw chains of men and women hauling on long ropes, dragging great rough stones on log rollers to build Stonehenge, and smoother stones to build pyramids in Egypt. We saw Christ on the cross, Mohammed riding a camel toward a mosque, Buddha smiling.

We saw men with stone axes felling trees and burning the hearts out of dry logs to make dugout canoes. We saw men building sailing ships and locomotives and rocket craft. We saw rockets landing on the Moon, saw old Calvin DeFort building Tycho Station and Sandor's great digging machines plowing it out of the crater slope where the lunar impact had buried it.

Finally we saw ourselves, as Sandor had restored us. Awkward stiff-faced robots carried sleeping babies out of the maternity lab. We recognized ourselves as toddlers learning to walk, laughing at one another when we made great leaps to the ceiling of the gym and fell sprawling on the floor. We wiped our eyes when we saw Tanya and Dian as small girls, sitting on Sandor's knee and giggling at the antics of a doll he had given them.

Finally, when the wall went blank, Pepe embraced me. We clung together, weeping with loneliness and grief, till at last he pulled away and begged the robots for more wine. Instead, they helped us to our rooms. I let them undress me and get me into bed. I woke late from a dream where I was still at the station, at odds with Arne over an illegal move he had made at chess. My head splitting, I stumbled out to the dining room to beg for coffee. The breakfast table was set, the sleek white robots

standing behind our chairs, but Pepe's chair was empty.

When I went to his room, he was gone.

7.

The robots had made Pepe's bed, but they stood silent, cold eyes blindly staring, when I asked them where he was. In panic, I searched every room and closet in our apartments, finding nothing at all. Still half drunk from too much wine, I stumbled out to see if he taken the remaining slider pod. It lay in the dog town where we had left it, empty when I looked inside.

A savage anger stunned me. I loved Pepe, my loyal companion since the days back at the station when Arne tried to bully us. Why had he left me abandoned and alone, the last man on Earth, perhaps the only man alive in all the Universe? Betrayed, bitterly bewildered, I sat at the jade table till that irrational anger had faded into sobs of helpless grief. Finally I lay back on the bench and slept off the wine.

That long afternoon I walked out to the cairn where we had buried Casey and the wreck of his slider, hoping dimly to find Pepe there. He was not, but I knelt by the mound, groping in my memory for *The Lord's Prayer* and *The Twenty-third Psalm*, which my holo father had tried to teach us. I myself have no belief in life after death or anything supernatural, but with no will to leave, I knelt there for hours, droning the words I could recall, my last link with the old Earth.

A purple dusk was darkening in the east before I stood up and plodded back toward the Crown. Lit by a red sunset, its golden dome towered over me like a fallen Moon, half buried when it fell. I stopped and stood there, shivering in a cold night wind. It was too huge, too long dead, haunted with the ghosts of too many worlds.

Yet it was now my only home, my prison too, so long as the white robots

wanted to feed and house me. Was Pepe somewhere there, lost in its endless warrens, perhaps ill or injured or driven mad? I had to find and help him if I could.

The robot guards let me in. The dark halls lit my way to our apartments. The robot staff served me a solitary meal and followed me to my lonely room. That night I slept badly, tormented by a bizarre dream that Pepe was calling me back to the dining room.

He said the robots had dinner waiting for us both. Finally wakened, I knew it was only a dream, yet I dragged myself out of bed and stumbled back to the table. Lights came on as I went, but no dinner was set. The room was empty till a silent white robot glided silently to stand behind the single chair.

I sat there till my eyes ached, staring at the holo wall, where a swarm of monsters never born on Earth were swimming though a jungle of enormous crimson worms grown up around a mushroom of black smoke spewing out of an undersea vent. I sat there till a robot shook my arm and asked how it could serve me. Half awake, I thought I heard Pepe's urgent voice.

"*Escucha*, Dunk. Listen! I'll reach you if I can."

I rubbed my eyes and tried to listen, but all I heard was silence. Stiff and cold from sitting there too long, I stumbled to my feet and let the robot escort me back to bed.

Next morning I ate alone, facing Pepe's empty chair and hardly aware of what the robots offered me. With no purpose or hope for anything better, I let them massage me and spent a long time in the shower. At last, searching for a better grip on my own sanity, I went back to the Earth sector.

Could Pepe be there? As much as I hated its empty stillness and all the riddles of its death, I had nowhere else to look. It had been a city in itself, the main street a great, high-arched hall. Black

darkness faced me it as I entered, but hieroglyphic signs flashed to greet me and the ceilings began to glow. Section by section; they lit my way past dark doorways and across darker intersections, until I came out again on that high balcony that looked down into the vast black chamber at the city's core.

Vertigo froze me. Waiting for those strange constellations to light the dome above, I had to fight a sudden mad impulse to jump the railing. Had Pepe chosen that escape? I could hardly blame him if he had, but I wasn't ready to die.

Shivering from the chill of panic, I swayed against the railing, feeling suddenly so weak that I thought I might topple over it in spite of myself. I gripped it till I got my balance back, pushed myself away, and stumbled off the balcony before there was light enough to let me look for his body on the distant floor.

Back in the lighted corridor, I leaned against a wall, breathing hard and gulping against a sour nausea, till at last I found the will to move along. With no hope left of finding Pepe or his body, or anything at all, I blundered on though an endless maze that always lit to greet me and fell dark again behind me.

The lights around me were suddenly red, so dim I felt blinded. Sign were fainter, stranger. Shop windows held nothing I could recognize. The icy air had a strange, bitter bite that troubled my stomach again, and a sudden gust sent a shudder through me.

I had strayed into a sector whose people had come from some colder star. Lost from anything I knew, with no sense of where I was or how to find myself, I was paralyzed with a senseless terror, left with no interest in who they had been or how they had died. All I wanted was to get out. All sense of direction was gone; I stood there, sick and shivering, till a noiseless robot loomed out of the red shadows.

It had the shape and grace of the white humanoids in our quarters, but

bright black scales covered it, instead of simulated skin. It stood motionless before me, speaking, perhaps, in some electronic language I did not hear. Its blind lenses unnerved me. When I tried to move aside, it glided to block my path again.

I turned to run. It caught my arm and held me with an iron grip until a more familiar white robot came to at last to guide me back to our apartments. Another stood waiting to serve me dinner. I left the meal untasted, drank all the wine it offered, and finally let it assist me to bed. Lying there, hopelessly mourning all I had lost and feeling that I would never sleep, I heard Pepe calling me.

I thought it was another dream.

"Dunk?" His anxious shout came through a rattle of static, as if from somewhere far away. "Dunk, can you hear me now?"

Groggily, I tried to answer.

"Dunk!" His voice was suddenly loud, near me in the dark. "Are you okay?"

I sat up on the side of the bed, fumbling for the light switch. The room lit before I found it, something shining from toward the door. A little cloud of milk-white mist, it glowed with swirling points of many-colored frost. It drifted around the room as if searching and finally paused to hang near my face. I reached out to see if it could be real. A hot spark from it stung my hand.

"Don't!" It spoke sharply. "*¡Por favor!* That hurt. Don't try to touch me."

"Pepe?" Searching for him, I scanned the empty floor, peered into the empty corners of the room, blinked into the empty air around the cloud. "Is this you?"

"*Sí. Soy tu compadre, Pepe Navarro.*"

"Pepe?" The voice was his own, but I cringed away from the cloud. "I was afraid—" I had to gasp for my breath. "Where have you been?"

"Everywhere. Or nowhere. If I can make you understand."

I sat there on the edge of the bed,

shivering and trying to see some shape in the cloud, perhaps Pepe's face. It was almost the size of his head, but all I found was the dance and swirl of those diamond sparks. They made a faint frying hiss.

"How?" I whispered. "What is there to understand?"

"The nanorobs," he said. "They've simply learned to reprogram themselves."

I leaned closer, listening. The cloud drew back.

"*¡Cuidado!* Not too near. The atmosphere is smothering me. Even your breath gives me a twinge."

"I thought—" This was nothing I could understand. "I was afraid you were dead."

"*Estoy vivo.*" The voice had Pepe's slight Spanish accent, but edged with a faint electronic hum, and now I began to catch something of Sandor's dry precision. "More alive than ever."

The cloud dimmed suddenly and darted away, toward the far corner of the room.

"Sir?" A white robot was calling from the doorway. Another came behind it. "Have you trouble? May we assist you?"

"Get them out!" The voice had weakened. "*¡Rápido!*"

"No trouble," I called to the robots. "Please leave the room."

"Sir, you should be sleeping." They glided on to seize my arms and lift me off the bed. "Are you in pain?"

The cloud had dimmed till I could hardly see it.

"Now!" Pepe's voice came faintly. "Their radiation! It's killing—"

"I'm okay." I wrestled free. "I need no help."

"Sir, you seem—"

"Get out!" I waved them away. "Now!"

They looked at the flickering cloud, swung to face each other, and finally glided out of the room. I sat back on the bed and watched the cloud brighten and drift back to me.

"*Gracias*. Their radio spectrum interferes with mine."

"Can you—?" I tried to swallow the rasp in my throat. "Can you tell me what happened to you?"

"I come—for that." He spoke in brief phrases, as if each took an effort. "Not easy. Hurts like hell. But had to let you know what I can."

"If you're real." I had to shake my head. "If you can."

"I'll try. But Earth's alien now. Hard to push through. I can't—can't last—"

The cloud dimmed and sank toward the floor.

"Pepe?" I leaned closer, groping for anything I could believe. "Come back! Tell me where you are."

"Out in space." The cloud brightened and the voice came faintly back. "With Casey and Mona and all the others. Sandor tried to explain how we came up. More than I understand."

I leaned closer, trying to hear. It darted back.

"Not too close. I don't belong here."

I drew back and heard Pepe laugh.

"*¡Compadre mio!* If you could see your face. Remember all the times you laughed when I crossed myself or spoke of *fantasmas*? Life after death was only superstition, you said, born when primitive people tried to explain the dead loved ones they saw in their dreams? Maybe it was, but now we are alive."

I did remember.

"If Sandor explained—" I shivered and swallowed again. "What did he say?"

The diamond flakes spun faster.

"The nanorobs?"

"You know their history." The voice spoke slowly but more clearly. "They were microscopic robots, created to assist our bodies and our brains with everything we did. They were self-replicating, half-mechanical, half-alive. They depended, as we did, on biochemical processes, yet their energies were always electronic. Sandor says they evolved as we carried them out to

space, till they could do more for us. Do it better, finally do it all. Our bodies were no longer necessary."

I shrank from the cloud.

"Still the skeptic, Dunk?" I heard Pepe chuckle. The diamond atoms burned brighter and his words flowed more freely. "Sandor says their silicon and diamond and gold were never more than vehicles for complexes of electromagnetic energy. Sandor thinks the evolutionary jump took place in the bodies of people dying in space. The nanorobs adapted and lived on, in the charged particles and magnetic forces in the interstellar clouds of dust and gas."

"If they were doing all that—" I thought of the dead Earth, the ghostly emptiness of the Crown, the mummies we had found at the satellite station. "Why didn't somebody tell us what was killing all the planets?"

"Nobody knew." The dance of light slowed for a moment and spun fast again. "The nanorobs were designed to be part of us, Sandor says, but never a conscious part. Never with a voice to tell us anything. One by one, flowing with the cells in our blood or working in our brains, they were nearly nothing. All their strength came from their unity. They had to act in unison to make the change, and never in any conscious way."

The diamond sparks dimmed a little as he paused.

"So they killed you?" I tried to believe. "Killed everybody? And you like it?"

"They've set us free!" His voice quickened. "You should see Casey and Mona! They are splendid! Larger than they were on Earth, with no air drowning them. Changing shape as their feelings change. Spreading wings of light that shine like rainbows. They all glowed with love, and they long for you to join us."

I pinched my arm and felt the twinge of pain.

"You will, Dunk." The spinning sparks had paled, his urgent voice

speaking faster. "You will believe when you get here. When you find your new senses, test your new perceptions. You can look out to the edge of the Universe and back through time to the big bang that made it. You can feel space expand."

The cloud was hard to see.

"I felt your shock and sadness." His fading voice was hard to hear. "I had to try. To tell you what I can. To ease your pain if I can. I've stayed too long. *Hasta tu muerte.*"

"Until I die?"

"Till you live again." The bright mist contracted, the diamond sparks only a fading point at its heart. "*Adios, compadre.*" His voice died into a crackle of static as I caught his last words. "*Qué te vaya bien.*"

The cloud was gone, like a blown-out candle.

8.

That glowing cloudlet still haunts me. I hated to believe that the microscopic machines in my blood were going to kill me, but the sting of the spark and the crackle of static had been too real to doubt. Wrestling with dread of it for the rest of that night, I felt desolate. Life all alone was no life, yet I wasn't ready to die.

A sleek white robot was standing by the bed when I woke, silently ready to massage me, to watch me through the exercises our own ungainly robots had taught us in the big centrifuge on the Moon, to hand me a heated towel when I came out of the shower. Another was waiting in the dining room to pull out my chair and offer a breakfast I failed to enjoy.

I felt glad to get out of the building even into the ruins around it, relieved to feel the morning sun and hear live birds chirping in the trees. I needed the company of anything alive. On my way out to the prairie dog town, I clambered again through that water-worn gap in the pavement and stopped to watch a

sparrow flying with a twig to its nest. I felt a faint pleasure in the shimmer of the rising Sun on the clean curves of the slider pod, even if there was nowhere for it to take me. I sat at long time at the table beside it, watching the tiny dogs. They had barked and hidden from me, but soon they were back again, sometimes standing up to watch me, but most of them scurrying about their business in the grass. I envied them.

My time goes on, even though I have no calendar or clock to keep account of it, nor any reason to. I live alone in this magnificent monument to human achievement, now the tomb of its builders. The white robots tend me well. Thanks to the nanorobs flowing in my blood, my health is excellent. Pepe keeps calling in my dreams, begging me to follow him into a finer paradise than any of the old religions ever promised. He says he is rejoicing in the wonders of new sciences, new arts, new philosophies, though I can seldom grasp anything he says about them.

He says his own senses are still expanding with his growing grasp of space and time. The past is fixed, he says. He can explore it, but never change it. He has looked back to watch that great asteroid strike the Earth. He has relived the drama of the escape, when El Chino drew his gun to bring Mona aboard. He has seen his parents alive and watched his own birth. He speaks of Casey and Mona, of Sandor and Lo, of multitudes of happy friends he found.

He says we'll all of us be merging ourselves in the vast cosmic mind, which will have a place for every intelligence that ever existed, anywhere. That prospect frightens me, but he laughs at my alarm. He says we have no loss to dread, says we will still be ourselves, keeping our own conscious identities, our individual freedoms of thought and action.

Perhaps. I want to deny it, but he insists that that my own Sagittarian

nanorobs will grow to convince me. He urges me to hasten the time when I can tell him I am ready. If that is left to me, I want to live forever. Though a desperate loneliness still haunts me, life is far too precious to be surrendered for any dream of eternal enchantment somewhere off in the sky.

I enjoy the birds and squirrels that are old friends now, the little dogs barking around me, the little owls that live with us in our little town. The larger animals seem wary of the ruins, but sometimes on good days I walk out to watch the elephants and impala and zebras trailing toward the waterhole. A sleepy lion is often watching from some high place. A leopard or a cheetah now and then dashes out of cover in pursuit of its next meal, but they all ignore me. Perhaps the nanorobs somehow protect me.

Though the immensity and the strangeness of the building is still overwhelming, I have set out to explore the Earth sector, mapping it as I go. I have begun to learn the simple oral talk of the robots. Electronic speech still baffles me, but now and then a street hieroglyph reveals itself, inviting me to visit a gallery of interstellar art, a lecture on galactic history, a sale of prehistoric antiquities, a symposium on the future of nanorobic technology. My own nanorobs may finally teach me their electronic language. The great building is a world of wonders I can never exhaust. Lonely as I am, I should never be bored.

I have a small telescope I found in a science museum. Sometimes on a clear night I take it outside. When I see the stars of Sagittarius, I find it hard to believe that I have been there among them, and skipped a millennium of time. More often I wait for moonlight for an-

other look at Tycho and the rays spread around it.

I know the station is still there; we saw the mirrored dome on the crater rim from Sandor's slider pod. It is now asleep, but I know its instruments are still scanning the Earth for evidences of human life. When they warn the master computer that the Earth is empty, we may be cloned once more, to repeople it again.

If that takes place, I may be alive to greet myself, or my clone, arriving from the Moon. Though I feel a certain unease in the contemplation of that possible event, I expect to make him welcome. From the beginning, we have been the station historians. I am leaving this narrative for his information.

It must wait here for his arrival. I have no radio that can reach the Moon. Even preparing this manuscript has been a problem. People in instant contact and endowed with permanent memories have little need for paper or pens. I had to search a vanished artist's studio for pencils and drawing paper. I will leave the finished document in my room, with the robots instructed to show it to anybody who enters the building. I believe they have understood me.

Living in my own fading recollections, I know Tanya has been dead these thousand years, buried under the gray Moon dust down below the Tycho wall, along with all our other siblings who have died there; and dogs I used to own. Yet I don't forget her tears, her tight embrace, our last passionate kiss when we had to say good-bye. Sometimes in my dreams she has been cloned again, and returned to Earth again, as fresh and bright and lovely as she always was.

Life has always been uncertain, but it renews itself.

Or so I dream. ■

Correction:

On p. 81 of "Kaddish for the Last Survivor" by Michael A. Burstein [November 2000], Sarah should roll up the sleeve of her left arm, not her right. We apologize for the error.

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THE REFERENCE LIBRARY Tom Easton

Marrow, Robert Reed, TOR, \$25.95, 352 pp. (ISBN: 0-312-86801-4).

Crescent City Rhapsody, Kathleen Ann Goonan, Avon, \$24, 430 pp. (ISBN: 0-380-97711-7).

Mars Crossing, Geoffrey A. Landis, TOR, \$24.95, ? pp. (ISBN: 0-312-87201-1).

Man of Two Worlds: My Life in Science Fiction and Comics, Julius Schwartz with Brian M. Thomsen, Harper, \$14, 197 pp. (ISBN: 0-380-81051-4)

Lemady: Episodes of a Writer's Life, Keith Roberts, Wildside, \$30, 168 pp. (ISBN: 1-58715-031-X).

Ghosts Who Cannot Sleep, Alan Rodgers, Wildside, \$15, 120 pp. (ISBN: 1-58715-106-5).

Sister Emily's Lightship and Other Stories, Jane Yolen, TOR, \$22.95, 300 pp. (ISBN: 0-312-87378-6).

Engines of Tomorrow, Robert Buder, Simon & Schuster, \$27.50, 447 pp. (ISBN: 0-684-83900-8).

Al Azif (The Necronomicon), Abdul Alhazred, Wildside Press, \$25, unpaginated (ISBN: 1-58715-043-3).

Lafferty in Orbit, R. A. Lafferty, Wildside Press, \$15, 220 pp. (ISBN: 1-880448-68-8).

One of the classic SF modes is "Look! It's Coming! What Is It? Let's Go See!" Just in the last few months, I've discussed two fine examples from the keyboards of Greg Benford and Nancy Kress. Now we have another, Robert Reed's *Marrow*.

The tale opens as a cratered world approaches the Milky Way. Robot craft from thousands of species and worlds fly out to meet it and goggle at the monstrous rocket nozzles protruding from its backside. Then come the living beings, and humans are the first to enter, begin exploring a vast labyrinth of corridors and chambers, and fight off the second-comers. It is theirs now, and if they can just figure out how to repair the great ship's assorted systems, they can have a treasure.

Where did the ship come from? There isn't a clue, although it has clearly been on the way for millions of years. Who built it? Again, no clue, not even traces of ancient organic materials. The ship is sterile, voiceless, a shell waiting to be filled.

The humans are a highly engineered breed, virtually immortal. Under the leadership of the Master Captain and her sub-captains, all dressed in mirrored uniforms, the ship is brought back to function. Chambers are turned into habitats. More humans come, settle in, and begin to multiply. The ship's path is bent toward the galactic core, and the word goes out: It is a passenger liner, a cruise ship, an adventure, and all who are rich enough to buy a ticket, no matter their species, can come aboard.

The ship's speed is great but still slower than that of light. The cruise is long, a matter of millennia, and it is thus rather convenient that the captains and stewards and the rest of the crew are immortal. Meet Miocene, the Master's aide. Meet Washen, born aboard, grown to Captaincy, a meet and greeter of aliens for the last fifty thousand years. They have friends and lovers, and an abiding mystery—the nature of the ship, its builders, its rationale, its function—to keep them from growing bored.

Then, one day, the Master informs a

chosen corps of Captains that the center of the ship is hollow, and within it rests a Mars-sized sphere of iron, the core of the planet that had been shaped into the ship. It looks like cargo in a hold, and thus the best clue anyone has yet found to the mysteries of the ship. Better yet, this internal world—call it Marrow—bears on its surface life, a biosphere.

The Captains' new assignment is to explore Marrow. Unfortunately, before they can complete that task, the iron globe convulses in such a way as to destroy their technology and their return to the upper levels of the ship. They are stranded until they can build a technological civilization able to recreate that return route. It will take millennia, but they're immortal. All they need to do is breed and wait.

And watch their children begin to imagine that they are the reincarnations of the ancient Builders and that there was a war with a ferocious enemy. In due time, the Captains' technology is restored to the point that they can tell that there is another sphere deep within Marrow.

When Miocene and Washen finally escape, they quickly find that things are not what they seem. There is chaos and war, and in the end a very satisfied reader.

But that's just what one expects from Reed. He rarely disappoints.

Nanotechnology has been big in SF for the last few years, with numerous novels concerning its wonders and threats. Just in the last year or so, I've covered works by Brian Stableford, Linda Nagata, Ken MacLeod, and more. Meme wars have been big too, with John Barnes in particular writing about computer viruses that can adapt themselves to any operating system, including the human brain's.

Put 'em together, and what have you got? Kathleen Ann Goonan's *Crescent City Rhapsody*, whose events begin in 2012, when a mysterious electromag-

netic pulse fries the world's circuitry. Fortunately, Zeb, a radio astronomer whose manic genius is restrained by medication, has a tube-based receiver on a Virginia hilltop and realizes the EMP carries a message from the stars. Unfortunately, the government has caught on too; soon he is on the run, even as hundreds of children are born with strangely altered brains (perhaps connected to magnetite deposits in their heads). Since the pulse keeps repeating, it is soon clear that we will never again have the radio, TV, and Internet we had grown used to.

We need something else. Fortunately, nanotech is past the embryonic stage—it is good enough to save Marie Leveau, descendant of the New Orleans Voodoo Queen and a city power in her own right, when she is assassinated. Soon folks are talking about using pheromones to transmit information through the living veins of BioCities, with people transformed to suit the new technology.

Scary stuff, and a nice reification of the grand fear of tech critics that technology—not people—calls the shots. The fear is justified when the conversion process goes awry and people become zombies and robots, ruled by the nanotech version of meme viruses. But the tech can work, it can be corrected, and when it succeeds the result is marvelous.

It's a struggle to get there. But though Zeb is an obsessional street person, Jason flees the government thugs who are corralling the mutant kids for study, Ilrian vanishes into a secret lab, Kita is absorbed in creating disastrous nanotech, and Tamchu joins the terrorists, Marie is struggling to pull the threads together, to save New Orleans from international troops and the sort of nanotech surge that has already destroyed Kyoto and Washington, and to create a utopia on an artificial island.

Goonan writes with verve and skill. She has the gift of invention, she main-

tains momentum very nicely, and her novel is very easy to enjoy. But I did feel she went well over the top with her use of the technology. I've called nanotech the latest "magic wand" technology before, and so it is here. It can do anything, with a little help from DNA, computers, and pheromones. And when the bafflegab gets a little flabby, all it takes is a bit of jazz to make all right with the world.

Well, maybe. But I'm not convinced.

There have been so many Mars novels in the last year or so that it's hard to imagine how anyone could come up with something new. On the other hand, it is practically traditional to use familiar patterns in many genres and we should hardly hold it against Geoffrey A. Landis that he has married the Zubrin-style bootstrap Mars expedition with the desperate, against-all-odds trek across a hostile wilderness toward a sole hope of survival. In *Mars Crossing*, he's done an excellent job in a classic vein, and the result is a ripping good yarn.

The backstory: Two previous Mars expeditions have failed. Two Brazilian explorers perished at the North Pole, leaving their return ship waiting. An American crew perished further south, leaving an empty base and a never-used lightweight airplane, as well as an automated fuel factory and return vehicle, the *Dulcinea*.

Now it's the turn of the international free-lancers on the *Don Quixote*, financed in part by a lottery (grand prize: a ticket for the trip). The captain is John Radkowski, an American from the rough streets of Brooklyn and an astronaut hero, loaded with the Right Stuff. Estrela Conselheiro is another street kid and the widow of one of the Brazilians. Chamlong Limpigomolchai is the first to die and therefore undeveloped as a character. Tana Jackson is a determined achiever who must deal with racism. Ryan Martin is another Right Stuff hero. And "the kid who called himself Trevor Whitman" is the winner of the lottery,

supposedly over 21 but early clues say he isn't; he resents being treated like useless baggage but that's what he acts like and never more than when he's whining.

The landing is successful, right on target and just a few minutes' stroll from the *Dulcinea*. Sense of wonder oozes from the pages as the crew steps onto the Martian surface. But . . . Ryan thinks the telemetry from the *Dulcinea* isn't right, and when he and Chamlong finally get over there to check, he finds out why. Pipes rupture, liquid oxygen engulfs Chamlong, and they are stranded. No fuel, no return vehicle. Unless they can somehow trek to the Pole and the Brazilian rocket.

It's hopeless. Their vehicles just don't have the range. But it's their only chance, so they're off. Landis details the struggle day by day, alternating with flashbacks to the earlier lives of his characters. We learn who they are in terms of their pasts; we also learn that most of them have left bodies in their wake. For Radkowski, it's the brother who died in jail to put him on the right track; he carries enormous guilt. For "Trevor," a climbing accident that sidelined his older twin brother; no guilt at all. For Estrela, a murdered brother and a grim determination to survive. For Ryan, a fiancée and a bride; now he's stiff and dedicated. For Tana, a marriage, and if the bodies still lived, their loss still shaped her.

Radkowski is the next to die, when a rope snaps. Then it's "Trevor's" turn, sitting on a trove of fossils. And then . . .

It's in the nature of the improbable literary trek that someone survive. There must also be a villain, and justice must somehow triumph. So it is here as well, but I say no more except to recommend the book to your fond attentions.

The twentieth century wasn't two decades old when Julius Schwartz entered it, so he was there when genre science fiction was born. He met it early,

quickly became a founding fan and Golden Age literary agent, and moved on to be an influential editor of the super-hero comics, shaping both Superman and Batman. SF and comics fans will therefore be pleased to know that his autobiography—**Man of Two Worlds: My Life in Science Fiction and Comics**—is available.

In the way of autobiographies, this one casts individual light on people and events many others have discussed. It also highlights some less-known details, such as the time Hannes Bok put L. Ron Hubbard into a 1939 *Weird Tales* cover.

One more for the history shelf.

Keith Roberts's **Lemady: Episodes of a Writer's Life** is also autobiography, but it is much more to my taste. Roberts, the British author of *Pavane* (1968), *Kiteworld* (1985), and many other tales, has long worked in advertising, with stints as an editor as well. The title incorporates the pseudonym of a lady important enough in his life to become his icon or touchstone. She is in his mind when he meets other women, and in his writing when he devises the renowned Kaeti and Molly Zero, among others. She is also there as he experiences the worlds of advertising, commercial illustration, and publishing and garners the wealth of "episodes" that comprise this memoir and illuminate the recent history of our genre from a British perspective.

Roberts is a well-lettered fellow, and it shows. He is free with references to the best of literature, and his style is far from the unsubtle pulps that so enchanted the young Julius Schwartz. Interestingly, one feature of that style is a reluctance to pin down the events of his memoir with specific dates. The effect is the feel of memory, albeit massaged to a reflective gloss.

That this book is available speaks well for Wildside Press. Wildside is by no means a new house, but it has embraced the new print-on-demand technology

and leaped its list from a handful of titles (including this one—it came out in 1997) to hundreds. Most are reissues of older titles such as *The Necronomicon* (covered below). Some are new, or new to this side of the Atlantic. All seem well chosen.

Some of the new titles are collections such as Alan Rodgers's **Ghosts Who Cannot Sleep**. Rodgers was once an editor with *Night Cry* (*Twilight Zone*'s horror-oriented sister mag). Since then he has developed a reputation as a horror writer. On the evidence of this book, his kind of horror has a very modern feel, with little of the supernatural about it. "Mama's Ghost," for instance, follows Abbey, a young street waif, through the horrors of the urban streets, ending with the all too predictable consequences of drug addiction. The ghost of Abbey's mother is there, true, but she is a powerless onlooker, as is far too often the case for living parents whose kids take a self-destructive path.

In other tales, Rodgers considers how Paul Bunyan would feel if he could return and see what has become of the America he knew, a role reversal for Oswald and Kennedy, and how hard it must be to stop an egotistical blues singer who insists on singing the song meant to be sung only once, on Judgment Day.

Nice stuff.

Jane Yolen is a gem in the diadem of science fiction and fantasy. She has won the Caldecott Medal, the World Fantasy Award, and—for the title story of **Sister Emily's Lightship and Other Stories**—the Nebula Award. Among her most significant novels is *Briar Rose*, which I reviewed here in March 1993.

This long-overdue collection of twenty-eight tales includes the quite funny "The Uncorking of Uncle Finn," concerning the inevitable conflict between a holy elf and a drunken, pagan Abbott; the pithy "Creationism: An Illustrated

Lecture in Two Parts"; and the hilariously, scurrilously feminist "Dick W. and His Pussy; or, Tess and Her Adequate Dick." For lagniappe, if you need it, there are three stories never seen before in print.

You *will* enjoy this one.

Robert Buder's **Engines of Tomorrow** offers a very readable jaunt through the histories and accomplishments of several of the world's major technology companies—IBM, Lucent Technologies, Siemens, NEC, General Electric, Xerox, Hewlett-Packard, Intel, and Microsoft. In the process, Buder amply reinforces this early point:

"[C]orporate research [plays] a vital role in competitiveness. But despite a widely accepted view that research was important to corporate well-being and vigor, it wasn't until the 1950s and early 1960s that things really took off. That was when young Massachusetts Institute of Technology assistant professor Robert Solow showed mathematically—the basis for his 1987 Nobel Prize—that in the long run growth in gross national product per worker is not due so much to capital investment, the traditional pillar of classic economic analyses. Instead, such growth is in very large part the result of technological progress. In a nutshell, advanced economies grow largely on the strength of what one can call New Knowledge—in most cases the high-technology fruits of research and development" (pp. 16-17).

Despite projections that the pace of US innovation is falling behind that of competing nations, US patents, both here and abroad, are running ahead of expectations and the economy is humming very nicely. There was some serious retrenchment in the early to mid 1990s, but despite numerous cries of alarm about how U.S. industry was surrendering its hope of technological leadership by giving up research, it was essential to trim bloated research systems that were not well focused on corporate goals. In the last few years, says Buder,

these companies have trimmed their research departments and aimed them more at technology—products—than science. The results have been astonishing; corporate research is not dead, and indeed it has begun to grow again. We can expect the flood of innovations to continue and the pace of change to remain as fast as ever.

This is just the thing for a gang of techno-optimistic *Analog* readers. I don't think he's wrong.

Notable Reissues

The denizens of science fiction and fantasy have been fortunate for most of the last century, for they have been among the few living souls to have heard of the existence of Abdul Alhazred's *Al Azif* (*The Necronomicon*). They have also been fortunate in that they have very rarely been able to find a copy.

Fortunate, I say, because to read this compendium of ancient spells is to venture in peril not merely of one's soul, but even of one's life. L. Sprague de Camp reports in the Preface that he was once approached by a member of the Iraqi Directorate General of Antiquities who had a curious manuscript for sale. Since the price was right, de Camp bought it. Later he learned its curious history: After its exhumation in the village of Duria, several Iraqi scholars undertook in succession the task of translating the ancient Durian script reproduced here. Each one vanished, the last leaving the only signs of a violent fate behind, in the form of a spatter of blood about the walls and ceiling of his chamber.

Be warned. If you purchase this curious item, first mentioned in the seminal works of H. P. Lovecraft, do not attempt to translate it. Don't even try to read it in the original, especially if you have the least tendency to subvocalize or to move your lips when you read. Pronunciation apparently does not matter, which may explain why the Owlswick Press edition

of 1973 had such a brief life on the stands. Bookstore managers reportedly did not appreciate watching browsers vanish before their eyes, nor the task of replacing gore-splattered stock.

Perhaps the persistence of used copies, to be found only on the tables of the dealers in convention huckster rooms, explains the decline of fandom rather better than the usual hypotheses, which rely on the rise of television, movies, *Star Trek*, *Star Wars*, and their assorted spinoffs.

Hmmm . . . Do you think that if this book could be adapted as a radio, TV, or film presentation, and disseminated among the more crowded nations of the Earth, it might solve the population problem? I suspect not, for its effect upon producers, directors, and actors would surely make it impossible ever to complete the task.

On the other hand, it might hold an answer to the glut of producers, direc-

tors, and actors!

In its way as strange as the *Necronomicon* but much more readable is R. A. Lafferty's *Lafferty in Orbit*, nineteen of his tales from the long-gone *Orbit* anthology series.

Lafferty's style is arch and fey beyond compare. His tales are rife with unique and rare metaphors, images, and concatenations, and my favorite here is surely "Fall of Pebble-Stones," in which he addresses the mystery of why one finds rows of pebble on the ground beneath the eaves of houses. It is not just a matter of rain and erosion, he says (though I—benighted philistine!—always thought it was). The pebbles don't show up until after people move into a house, and if the folks are vile, they don't even then. There is a pebble fairy, you see . . .

Lafferty is a taste worth acquiring, especially at shorter lengths. Enjoy! ■

IN TIMES TO COME

Fran Van Cleave leads off our February issue with "The Mycojuana Incident," an engaging and irreverent tale of what happens when a big entity called government tries to fight a biological threat with a biological weapon. We're often told that attempts to deceive weave tangled webs, but those woven by individuals are as nothing compared to those when the tangled web of bureaucracy gets entangled with those of ecology and medicine. Organisms, after all, interact in a great many ways and combinations; and big government is the classic example of an organism whose left hand doesn't know what its right is doing. . . .

We'll also have a diverse assortment of other fiction, from Wolf Read's story of winged adolescents, to Shane Tourtellotte's look at a decidedly new version of a very old sport, to Grey Rollins' tale of a detective who must solve his own murder.

And Richard A. Lovett returns with "The View from Space," about the many ways remote sensing by satellite is changing the ways we learn about planets (including ours) and the contents thereof—some of which are clearly useful, while others have their scary sides

BRASS TACKS

This is a question for John G. Cramer, in response to his June 2000 Alternate View column. I enjoy reading the Alternate View Column each issue, and can usually follow the theoretical conjectures reasonably enough to not feel lost. (Although the Marinov motor a while back got me a bit dizzy . . .) The question I have with the column pertains to the use of a Mach-Zender interferometer (MZI) as a method of detecting photon-triggered "live bombs."

Specifically, on page 79, where Mr. Cramer discusses the implied results of the "photon bomb in the loop" testing. He states that "If the bomb explodes, we know that the bomb took the lower path." OK, I can agree with that. Then he continues "If it does NOT explode, we know that the photon took the upper path." Herein lies my first question. According to the very nature of quantum wave-theory, and the use of the MZI, doesn't a result wherein the bomb does NOT explode imply either that the photon took the "other" path, OR that the bomb was a "dud"? Mr. Cramer did not state that every bomb was a live bomb, and in fact states the converse—that there is a possibility for a "dud"—on the top of page 80. And, lastly, Mr. Cramer goes on to point out that, statistically, "50 percent of the time the bomb explodes" (OK, I can buy that), "25% of the time we will receive an inclusive D1 signal, and 25% of the time we will receive a D2 signal, indicating an unexploded live bomb." Here, one would think the receipt of a signal indicates that there is STILL THE POSSIBILITY of a live bomb on the lower path, but the very fact that the photon reached D1 or D2 indicates that the photon-triggered

bomb did not see the photon, and thus may or may not be live.

I am by no means a quantum theory expert, but something in Mr. Cramer's explanation just doesn't ring right. I'd love to discuss it with him a bit more, or possibly have him comment on where my understanding may not be accurate.

Thank you, and I would just like to say I've been an *Analog* reader for over 15 years, and look forward to many more years of reading your magazine cover to cover. The stories are great, and it's a pleasant surprise how often the science fact articles clue me in to something that ends up making news in the popular press 6-12 months later. Kind of like a reliable inside source for some of the most interesting new developments in various fields of science.

C.B.

The author replies

Dear C.B.,

I'm sorry that you found my account of an interaction-free measurement confusing. Let me try it again.

First, consider the case of a dud bomb. Because we described a dud as passing the photon on through unimpeded, it is equivalent to placing nothing in the path of either beam. In this case, the two beams will interfere, and we will detect the photon in detector D1 with 100% probability.

Now, consider the case of a live bomb. In this case, if the photon travels on the lower path (which it will do 50% of the time), the bomb will stop a photon (and explode). If the photon travels on the upper path (which it will also do 50% of the time), it can take either of two paths at the lower splitter. Therefore, we will detect this photon in D1

with 50% probability and in D2 with 50% probability.

Now let's total the results of sending a single photon into the interferometer: A dud bomb will ALWAYS result in a detection at D1. A live bomb will explode 50% of the time, we will detect a photon at D1 25% of the time, and we will detect a photon at D2 25% of the time. Therefore, detection at D2 ALWAYS means there is a live and unexploded bomb in the lower arm of the interferometer. An explosion (and no photon at either D1 or D2) also indicates a live bomb, but one that has been destructively detected in the normal classical way. The other possibility is that a photon is detected at D1. This eventuality conveys no information on the dud/live state of the bomb, but in this case we can send in another photon and try again. This can be repeated many times until (a) we detect a photon at D2, (b) the bomb explodes, or (c) we give up after many tries and declare the bomb a dud.

The net result is that we can identify essentially 100% of the dud bombs, because after a large number of tries, we always detect a photon at D1. We can identify 33% of the live bombs in an unexploded state, because after some number of inconclusive tries giving a detection at D1, we detect finally a photon at D2. We also identify 67% of the live bombs by exploding them after some number of inconclusive tries giving a detection at D1. The net result is that 33% of the time we are able to identify unexploded live bombs have not interacted with a photon. This quantum feat has no equivalent in classical physics.

I hope that is clearer.

John G. Cramer

Stan,

Your editorial in the July/August 2000 issue entitled "Blunt Instruments" is one of the best you have ever written; in fact, I thought it was almost perfect. I certainly agree with you that the imprecise use of language in general, and the

overuse of profanity in particular has become a blight on our culture.

The only point on which I disagree is your definition of morality; you wrote: "The only answer I have ever found that seemed logically defensible was that immorality means actions that harm people other than the one doing them."

The problems I have with that formulation is that first, it implies that morality depends on other people for its very existence and standard of value, and second, it means that killing someone in self-defense or in a just war defending the principles of the Constitution are inherently immoral because they harm others (a criminal or an enemy of the United States such as Hitler and his followers) rather than one's self.

Of the two, the first problem is the more fundamental and therefore the most important: If morality inherently depends on other people for its standard of value, then a solitary person is implicitly immoral (or at least amoral).

Yet as Ayn Rand pointed out many years ago, being alone on a desert island is when one would NEED morality the most. Moral choices of action are a subset of all available choices; they are the choices which are consistent with some standard of value (such as not harming others), as opposed to the immoral ones (which are not consistent with that standard of value). Whether a standard of value is subjective (religious or arbitrary), or it is objective (based on science and reality) is beside the point; every morality must have SOME standard of value that determines its definition of good and bad. While your standard of not doing harm to others is an objective, measurable standard, and therefore more scientific than subjective standards, it leaves the entire area of the solitary actions of an individual living alone in the wilderness or in a small spaceship undefined, and therefore such a person would have no means of determining good choices from bad ones; in other words, such a person

could not be moral by your definition of a standard of value.

In addition, this implication flies in the face of a fact that we all know very well: A solitary individual living in the wilderness or alone in space somewhere still needs to make choices to survive. In fact, such a person's choices are usually more difficult than those of a person living in a society; it is much easier to choose between carrots or mushrooms in the supermarket than between two plants in the woods, one or both of which may be poisonous. We also know that some choices of action (an edible plant) will necessarily lead to survival and some (a poisonous one) will necessarily lead to death; anyone who has gone wilderness camping knows that these are very real and objective facts. (And there are plenty of dead campers to prove it.)

These facts, therefore, imply an objective standard of value is required for human choices of action: That standard is LIFE. Using life as the standard, all choices of action that promote life are good (are values), and all choices of action that are anti-life are bad (are dis-values). Integrating all good choices of action into principles (such as always think before you act, test your food before you eat it, be honest, be productive, and so on) gives us a code of values of pro-life choices of action. To paraphrase Ayn Rand: A code of morality is a code of values accepted by choice.

The bottom line is that there is a chain of concepts and reasoning that leads from an observable, objective fact (man's need to choose actions to survive), to principles of survival (the science of survival with life as the standard), to a moral code which provides us with an objective, shorthand guide of good choices of action to seek out (survival), as opposed to bad ones to be avoided (death), and that is what an objective morality is.

Thus defined, an objective morality of rational self-interest does not depend on

other people and will work just as well in the wilderness or on a one-person spaceship as in a society. Morality is the science of long-term survival; it is an abstract, conceptual navigation tool for people to use to make the myriad of choices that are required OVER A LIFETIME in order to survive and attempt to gain what Jefferson so aptly called "the pursuit of happiness."

This is not the place to deal with all the potential objections you may have about selfishness, concerns over how people thinking only of their short-term self-interest could destroy society, or the "you can't go from 'is' to 'ought'" argument, which is a favorite of many philosophers. Those objections and many others have been dealt with in articles and books such as the "The Objectivist Ethics" by Ayn Rand or "Objectivism: The Philosophy of Ayn Rand" by Dr. Leonard Peikoff. The objections have also been dramatically demonstrated as false in real life by the collapse of Socialism throughout the world: It is precisely the lack of long-term self-interest and the inability to make objective moral choices by people living under Socialism (due to the constant threat of physical force) that has caused its destruction nearly everywhere. The few remaining pockets are such poverty-stricken warrens of death and starvation (such as North Korea) that no one in their right mind could still claim they are a "workers paradise."

I don't know if you will ever come to agree with me on this issue, Stan, but I hope someday you do. I am not trying to put words in your mouth, but if you change just the sentence I quoted earlier and the one following it to read:

"The only answer I have ever found that is logically defensible is that morality means an objective code of values, accepted by choice, with life as its standard. Profanity is not anti-life; it is..."

Then I think you will have written a perfect editorial.

Greg Czora

We're not so much disagreeing as using words differently. As I understand the term, morality refers specifically to judging rightness of actions affecting other people and so is a non-applicable concept in your person-alone examples. Certainly such a person needs a set of principles for deciding what to do, but I would classify those as something other than morality; I also would not presume to tell somebody else what criteria to use for formulating such a code for decisions affecting only himself.

Dear Mr. Kooistra,

In re: perfect-fluid-model aether

I wonder if you might address four questions in a future article;

a) What effect does light have on gravity? I am aware of the effect gravity has on light but not the converse.

b) Does changing light change its effect on gravity?

c) Has anyone done an experiment that compares the effect of laser light on gravity compared to a non-laser light of equal strength?

d) If you choose to use the aether model do you need particles and waves, or can you just use aether states to describe everything?

Thank you for taking the time to read this.

Jon Mishcon

The author replies . . .

I'll keep your first three questions in mind as I work on future "Aether pieces," but I think I can answer (d) quite easily for you here.

In the aether model I like, you have both particles and waves, but the particles are made up of the aether fluid, not some separate sort of matter suspended within it. "Particles" are dynamic structures—line vortices curled back on themselves seem to work well. The structure is long lasting, but the individual aether particles move in and out (much as the atoms of your body are not the same ones you had ten years ago). The structure is "solid" enough so that if you collide another one with it, they'll bounce off each other, which is what makes them particle-like.

Lord Kelvin spent a lot of time trying to figure out how to make atoms out of vortices. He couldn't do it since (1) he didn't know that atoms were made up of still smaller pieces and (2) computers weren't around to handle the nonlinear partial differential equations you have to solve to find stable solutions.

Jeffery D. Kooistra

Continued from page 6

what usually unspoken assumptions underlie that belief, and where there is still room for doubt. We must teach, in other words, not just "facts," but an awareness of the limits of understanding—and, perhaps most important, skills for critical thinking, which we must invite to be applied even to our own teaching.

A tall order, considering how difficult it can get to get many people to learn—or care about—even the simplest principles or facts. But if we can do it,

we may have real hope of the kind of lively, widespread dialogues that invigorate a culture.

And one of the first principles that needs to be conveyed is that facts *are* important. Opinions held without knowledge or regard for them are *not* as valuable as those solidly based on an honest attempt to understand reality, and encouraging people to believe that they are is just asking for trouble. ■

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UPCOMING EVENTS Anthony Lewis

27-31 December 2000

ARMAGEDDONCON (Israel SF conference) at Jerusalem, Israel. Theme: Armageddon, including an End-of-the-World ball on Mount Megidio. Guests of Honor—Larry Niven, Joan Vinge, and Paul McAuley. TM—Ian Watson. Join by 20 November and nominate for the Armageddon Award for best apocalyptic novel, novella, and short story. To be eligible, works must have been published since 1000 C.E. Registration—about US \$140 or NIS 550. Info—con@sf-f.org.il URL—<http://armageddoncon.org>. [this is a real convention]

12-14 January 2001

ARISIA '01 (Boston area speculative media conference) at Boston Park Plaza Hotel and Towers, Boston MA. Guest of Honor—Lois McMaster Bujold, Artist Guest of Honor—Wojtek Siudmak, Fan Guest of Honor—Wombat (Jan Howard Finder). Info—Arisia Inc., 1 Kendall Square, PMB 322, Building 600, Cambridge MA 02139. email—info@arisia.org. URL—www.arisia.org/2001.

12-14 January 2001

MARSCON 2001 (Tidewater Virginia SF conference) at Ramada Inn Historic, Williamsburg VA. Guests—Peter Schweighofer, Patty Jackson, Bud Webster, Rikk Jacobs, Luna-C. Fan Guests of Honor—Jeff and Sholom West. Secret Master of Fandom—Julie Wall. Registration—\$15 until 1 January 2001, \$20 at the door. Info: MarsCon, c/o James F. Allen, 429-7 Lester Rd., Newport News VA 23601. email—marscon@erols.com. URL—www.angelfire.com/va/marscon

12-14 January 2001

RUSTYCON 18 (Washington state SF conference) at Everett Holiday Inn, Everett WA. Artist Guest of Honor—Real Musgrave. Guests of Honor—Bob Mayer, Joe Dalton, Robert Doherty, Bob McGuire, Greg Donegan. Info—email—bobbied@microsoft.com. URL—www.rustycon.com.

30 August-3 September 2001

MILLENNIUM PHILCON (59th World Science Fiction Convention) at Philadelphia Marriott, Philadelphia, Penna. Guests of Honor—Greg Bear, Stephen Youll, Gardner Dozois, George Scithers, TM—Esther Friesner. Registration—\$145 [rates may go up]; supporting \$40. [These are the latest rates posted on the Internet as of the time this column went to press.] This is the SF universe's annual get-together. Professionals and readers from all over the world will be in attendance. Talks, panels, films, fancy dress competition—the works. Info—Philcon, Box 310, Huntingdon Valley, PA 19006. email—philcon2001@netaxs.com URL—<http://www.netaxs.com/~phil2001>.

26-29 October 2001

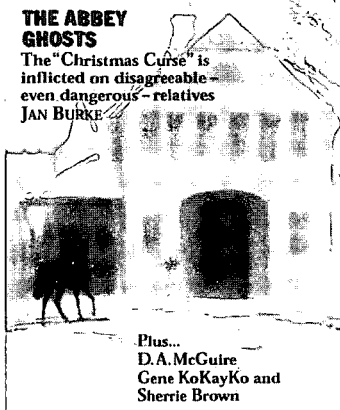
WORLD FANTASY CONVENTION 27 at Omni Bayfront, Corpus Christi, Tex. Guests of Honor—K. W. Jeter, John Crowley; TM—Joe Lansdale. Registration—\$105 until 15 October 2000, then more. Info—WFC 2000, Box 27277, Austin, TX 78755. +1.512.835.9304 (voice), +1.512.835.7637 (fax), email—fduartejr@aol.com URL—<http://2000.worldfantasy.org> ■

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